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Use of Laser for Separation of Carbon Isotopes During Two-Frequency Dissociation of Freons

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[Article by A.V. Yevseyev, V.B. Laptev, A.A. Puretskiy, Ye.A. Ryabov, and N.P. Furzikov, Institute of Spectroscopy, USSR Academy of Sciences, Troitsk (Moscow Oblast)]

[Abstract] Separation of ^{13}C and ^{12}C isotopes during dissociation of CF_2HCl (Freon 22), CF_2Cl_2 (Freon 12), CCl_2HF (Freon 21) molecules by means of a two-frequency pair of infrared lasers is analyzed, this method a being based on the isotopic selectivity of multiphoton dissociation of such molecules. An experiment was performed using two tunable transverse-excitation atmospheric-pressure CO_2-lasers with a 1:0.5:4.5 CO_2:N_2: He active mixture each. Radiation pulses emitted by them consisted of an 80 ns wide leading peak and a 1200 ns long trailing tail. The time delay between pulses was varied over the 0-1000 ns with a variance not exceeding plus or minus 50 ns. The molecules of all three freons had an intrinsic 1.08 percent ^{13}C-isotope content. Measurements during separation by this method have yielded the dependence of its selectivity and dissociation yield on the energy density of each laser radiation field, on the emission frequency of each laser, on the time delay between pulses, on the pressure of the buffer gas (Xe for CF_2HCl, 0_2 for CF_2Cl_2, N_2 for CCl_2HF), and on the intrinsic pressure of the dissociating gas, also the dependence of the absorption coefficient, of the average number of absorbed radiation quanta per molecule, and of the laser energy required for extraction of one ^{13}C atom on the intrinsic pressure of the dissociating gas in each laser field. On the basis of these data are estimated the performance characteristics of this separation method. The best results are evidently obtained with CF_2HCl molecules, laser beams with moderate energy density not exceeding 2 J/cm^2 being generally adequate. The authors thank V.S. Letokhkov for steady support. Figures 8; references 22: 7 Russian, 15 Western.

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Tunable Lasing of Cr^{3plus}-Ions in $BeAl_6O_{10}$ AT $^4T_2$-$^4A_2$ Electron-Vibrational Transition

18620137b Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 15 No 3, Mar 88 (manuscript received 21 Aug 87) pp 509-511

[Article by A.I. Alimiyev, Ye.V. Pestryakov, V.V. Petrov, V.P. Solntsev, V.I. Trunov, and V.N. Matrosov, Institute of Thermophysics and Special Engineering Office for Technology of Single Crystals, Siberian Department, USSR Academy of Sciences, Novosibirsk]

[Abstract] A new tunable laser operating at room temperature has been produced experimentally, namely a $BeAl_6O_{10}$: Cr^{3plus}-laser with Cr ions emitting radiation tunable over 790-870 nm range at their $^4T_2$ -$^4A_2$ electron-vibrational transition. Single crystals of the new active medium $BeAl_6O_{10}$, in the orthorhombic class, were grown by the Czochralski method and doped with Cr ions. The doping level was varied over 0.05-0.2 wt.pct Cr range and about 0.08 wt.pct Cr found to yield the best optical quality. The absorption spectra at both room temperature and 77 K, with the electric field parallel either to the a-axis or to the b-axis, contain two high-intensity bands within the 400-600 nm range and two narrow peaks near the longwave edge: at 688.0 nm and at 697.7 nm. Excitation by 532 nm radiation from a YAG:Nd^{3plus}-laser yielded luminescence with intensity peaks at 807 nm and 300 K and, unexpectedly, also at 735 nm, 715.9 nm, 692 nm at 77 K. The amplification curve indicates an approximately three times higher intensity with the electric field parallel to the a-axis than with the electric field parallel to the b-axis. The relaxation spectra and the temperature dependence of the lifetime of excitation states were recorded with Cr ions excited wither by pulses of 2000 ns duration from a YAG:Nd^{3plus}-laser or by pulses of 200 ns duration from a 650 nm dye laser. The emission quantum yield at room temperature was measured by the relative method with an Al_2O_3:Ti^{3plus}-laser (about 0.7 wt.pct Ti) as reference, both lasers being excited by pulses of 200 ns duration and 3.2 W average power at a high repetition rate of 6.3 kHz from a YAG:Nd^{3plus}-laser. The authors thank V.P. Chebotayev and G.V. Bukin for support. Figures 3; references 2: Western.

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Differential-Absorption Lidar With Transverse-Excitation Atmospheric-Pressure CO_2-Laser

18620136f Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 15 No 1, Jan 88 (manuscript received 3 Nov 86) pp 212-217

[Article by S.F. Kolyakov and L.P. Malyavkin, Institute of Spectroscopy, USSR Academy of Sciences, Troitsk (Moscow Oblast]

[Abstract] An infrared lidar with a TEA CO_2-laser has been developed and built for atmospheric sounding, namely determining the concentration profiles of gaseous impurities in air, by the method of differential scattered-light absorption. The laser operates alternately at two wavelengths corresponding respectively to maximum absorption and minimum absorption by target molecules, switching from one wavelength to another being done by rotation of a diffraction grating with an electromagnetic coupling through two given angles. The laser beam after its shift due to rotation of the diffraction grating has been compensated, passes through a reflecting transmitter and Newton receiver telescope along its horizontal axis of rotation while a smaller expander

mirror with x7 magnification on that axis inside minimizes the laser beam divergence (a lens being less desirable because of dispersion effects) and then impinges on a HgCdTe photo-receiver layer. This lidar was tested in ammonia. It was found to be more sensitive and accurate than a Raman-scattering lidar, but also more limited in scope to gases with a large absorption coefficient. Its range is 1 km, the laser with a 1:0.25:4 $C0_2$:N_2:He active mixture emitting pulses of 2 J energy and 100 ns duration at a repetition rate of 2-3 Hz while the wavelengths are switched at a frequency of 2 Hz. The receiver mirror is 45 cm in diameter and has a focal length of 1.5 m. The photoreceiver has an active an active area of 0.6x0.5 mm. Visible and ultraviolet lidars are still easier to design and build, owing to better sensitivity of photoreceivers and stronger backscattering of such light by aerosol combined with less stringent frequency stability and radiation intensity requirements for dual-wavelength operation. Figures 4; tables 1; references 13: 3 Russian, 10 Western (1 in Russian translation).

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Ionization of Active Medium of Traverse-Excitation CO_2-Laser by High-Intensity Picosecond Pulse of Infrared Radiation

18620137a Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 15 No 3, Mar 88 (manuscript received 4 Feb 87) pp 490-496

[Article by A.V. Novikov and V.D. Taranukhin, Moscow State University imeni M.V. Lomonosov]

[Abstract] Transient ionization by electron impact of gaseous mixtures constituting the active medium of TEA CO_2-lasers, mixtures of CO_2 molecules with N_2 molecules and He atoms, upon excitation by a high-intensity pulse of infrared radiation is analyzed theoretically assuming a pulse duration in the picosecond range. The equation describing the kinetics of the energy distribution of electrons in the field of such a pulse is formulated incorporating elastic and inelastic collisions, taking into account avalanche multiplication of slow electrons but assuming negligible inelastic losses and disregarding adhesion as well as diffusion of electrons over duration of the excitation pulse. An effective threshold for inelastic processes is introduced in lieu of accounting for differences between the ionization potentials of CO_2 and N_2 molecules as well as between the excitations of electronic degrees of freedom, nonelectronic degrees of freedom not being essential here. This equation has been solved by numerical integration with first-order precision by an explicit scheme, taking into account the rise of electron temperature during pulse action. Calculations were made for He-CO_2 mixtures with the He:CO_2 ratio either 9:1 or 5:5 as well as for pure He under a total pressure of 10 atm in each case, excited by pumping pulses of 10,000 nm radiation, 0.5-10 ps duration, and 2-2000 GW/cm^2 intensity. For the purpose of this analysis, the behavior of N_2 molecules is analogous to that of CO_2 molecules. The results reveal that generally the energy distribution of electrons will become quasi-steady only with a pumping pulse of peak intensity above a critical level and of duration longer than the corresponding minimum one. The critical intensity level, different for each gas composition, is that above which the dependence of the avalanche multiplication factor on the instantaneous pumping pulse intensity becomes ambiguous. The minimum pumping pulse duration, also different for each gas composition, is the threshold for an unambiguous avalanche multiplication characteristic and it becomes shorter with increasing peak intensity of the pumping pulse. Figures 5; tables 2; references 12: 9 Russian, 3 Western (2 in Russian translation).

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Effect of Hydrogen on Characteristics of Excimer XeC1*-Laser

18620136d Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 15 No l, Jan 88 (manuscript received 24 Jul 87) pp 112-113

[Article by A.N. Adkhamov, B.A. Azimdzhanov, T.U. Arslanbekov, V.I. Mikhaylov, A.N. Obichkin, I.M. Ternovskiy, and V.Ye. Chekalin]

[Abstract] An experimental study of the XeC1*-laser with electric-discharge pumping has demonstrated the feasibility of increasing its efficiency by addition of H_2 to the He-Xe-HC1 active mixture. Pumping pulses of 50 ns half-power width, produced by electric discharge of a capacitor holding a voltage of 18 kV across a 2 cm wide gap in series with a current transformer for measurements and in parallel with a preionization circuit, yielded emission pulses of 30 ns duration. While a 1000:10:1 He:Xe:HC1 active mixture yielded an emission pulse energy of 21 mJ at an efficiency of 1.5 percent, a 1000:10:1:1 He:Xe:HC1:H_2 active mixture yielded an emission pulse energy of 25 mJ at a correspondingly higher efficiency. Further addition of H_2 again lowered the emission pulse energy, down to zero as the H_2:HC1 ratio reached 3. Emission at two wavelengths, 307.8 nm and 308.0 nm, was recorded. Improvement of the laser performance is attributable to cooling of the electrodes during excitation of H_2-molecule vibrations and to transfer to vibrational excitation from H_2 molecules to HC1 molecules, recovery of HC1 molecules by synthesis reaction of H_2 and $C1_2$ being responsible for smaller variance of emission pulse energy. Figures 2: references 6: 5 Russian, 1 Western (in Russian translation).

2415/12232

UDC 678.535

Diagnostic Study of Phytoplankton by Method of Laser-Induced Fluorescence in Saturation Mode

18620136e Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 15, No 1, Jan 88 (manuscript received 26 Sep 86) pp 191-197

[Article by I.G. Ivanov and V.V. Fadeyev, Moscow State University imeni M.V. Lomonosov]

[Abstract] Application of laser-induced fluorescence in the saturation range to diagnostic study of phytoplankton is examined, the semiempirical theory of this method being based on the nonlinear fluorescence of chlorophyll-a which begins to saturate already at very low excitation levels. This is explained by singlet-singlet annihilation of excited states, following an analysis of absorption and excitation kinetics in accordance with the photosynthetic model and a quasi-linear dependence of the linearly extrapolated fictitious zero-excitation ratio of fluorescence quantum yield to Raman scattering yield on the chlorophyll-a concentration in phytoplankton. The theory was verified and the method, using second-harmonic radiation (532 nm wavelength) from a YAG:Nd^{3plus} laser for excitation of fluorescence centers, was calibrated against the standard method of extracts on pure cultures and three seaweeds (Olistodiscus luteus, Prorocentrum micaus, Exuviaella cordata) grown in the General Ecology and Hydrobiology Laboratory of the Department of Biology at the Moscow State University. The authors thank L.V. Ilyash for supplying the seaweed cultures and for determining the chlorophyll-a concentration by the standard method. Figures 3; tables 1; references 11: 10 Russian, 1 Western.

2415/12232

UDC 621.375

Effect of Vibrational Relaxation of Emission Quantum Yield of Excimer KrF-Laser

18620136c Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 15 No 1, Jan 88 (manuscript received 17 Feb 87, after completion 1 Jul 87) pp 106-108

[Article by V.V. Datsyuk, I.A. Izmaylov, and V.A. Kochelap, Institute of Semiconductors, UkSSR Academy of Sciences, Kiev]

[Abstract] Electron-Vibrational relaxation of excimer molecules in a Kr-F_2-Ar active mixture, where 10 processes with known rates and 3 processes with known time constants occur, is analyzed theoretically in the diffusion approximation and accordingly on the basis of the Fokker-Planck equation, considering that VT-transitions in such molecules are multiquantum ones and that the vibration-energy distribution of molecules in each bound electron-excited state is describable by a smooth function. The emission quantum efficiency of a KrF-laser, namely the ratio of its stimulated-emission rate to the pumping rate, is expressed as a product of two factors. the first one, in the usual form, is associated with photoabsorption. The second one represents the effects of excitation and extinction as well as of VT-relaxation. Figures 2; tables 1; references 11: 5 Russian, 6 Western (1 in Russian translation).

2415/12232

UDC 621.373.826.038.825.2

Miniature Color-Center Lasers With Extremely Low Emission Threshold

18620136a Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 15 No 1 Jan 88 (manuscript received 13 Apr 87) pp 47-49

[Article by Ye.F. Martynovich, V.I. Baryshnikov, V.A. Grigorov, and L.I. Shchepina, Scientific Research Institute of Applied Physics, Irkutsk State University imeni A.A. Zhdanov]

[Abstract] An experimental study was made concerning the feasibility of exciting miniature color-center lasers with high-power beams of low-energy electrons. Tests were performed in LiF crystals with F_2 and F_2^{plus} centers, such crystals being bombarded with electrons which had been accelerated to up to 0.3 MeV energy and being pumped with second-harmonic radiation from a tunable LiF:F_2^{plus}-laser in pulses of 25 ns duration. This experiment was conducted in the Semitron-1 nanosecond high-current electron accelerator built for this purpose and operating by the mechanism of explosive emission. Measurements have established the dependence of luminescence quenching on the concentration of color centers and their maximum concentration to which nonradiative energy losses will begin to occur during their excitation. The dependence of the luminescence quantum yield from F_2- centers on the absorption coefficient within the peak of the M-band was also established the yield remaining fairly close to 1.0 over the frequency range up to 300 cm^{-1} and dropping to zero at a frequency not much higher than 400 cm^{-1}. The laser emission energy was found to increase more than linearly with increasing pump energy, owing to the small optical thickness of the lasing layer, except over the linear low-energy range conforming to the Bouguer-Lambert-Beer law. Factors degrading the laser performance are poorer tunability of the confocal cavity and higher diffraction losses as the lasing layer thins down, also nonuniform power density distribution over the cross-section of the pumping laser beam. The emission thresholds for F_2 and F_3^{plus} centers in a cavity formed by an opaque mirror and a sapphire plate were found to be 4 kW/cm^2 (3.10^{-6} J) and 60 kW/cm^2 (45.10^{-6} J) respectively. Figures 2; references 6: 5 Russian, 1 Western.

2415/12232

UDC 621.373.826.038.825.4

Effect of Doping on Threshold Characteristics of GaAs-Lasers

18620136b Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 15 No 1, Jan 88 (manuscript received 6 Nov 86) pp 78-84

[Article by B.M. Lavrushin, R.F. Nabiyev, and Yu.M. Popov, Institute of Physics imeni P.N. Lebedev, USSR Academy of Sciences, Moscow]

[Abstract] The effect of doping on the emission threshold characteristics of GaAs-lasers is evaluated theoretically according to the band-to-band transitions with conservation of quasi-momentum. The energy spectrum of holes in GaAs thus contains acceptor levels as well as sub-bands of light and heavy holes, while all electrons are contained within the conduction band and donors are ionized. Both conduction and valence bands are characterized by a parabolic dispersion law, with the effective electron mass equal to $0.07m_0$ and the effective hold mass equal to $0.5m_0$ (m_0- mass of a free electron). The density of states on bound acceptors has a Gaussian distribution with a maximum at E_V- E_A and with a half-width depending on the acceptor concentration. Radiative recombination of excess charge carriers occurs along two channels: from conduction band to valence band with conservation of the electron quasi-momentum and from conduction band to acceptor band without conservation of the electron quasi-momentum. Analytical relations based on this model are used for numerical calculations which yield the dependence of the concentration and the generation rate of excess charge carriers on the net impurity level N_A- N_D over the -10^{19} cm^{-3} to 10^{19} cm^{-3} range (N_A- acceptor concentration, N_D- donor concentration), the dependence of the threshold current density for an n-GaAs laser with transverse electron-beam excitation on the donor concentration N_D, and the temperature dependence of the threshold current for n-GaAs and p-GaAs lasers with various impurity levels including zero N_A and N_D. Calculations made for GaAs lasers temperatures of 300 K and 80 K have yielded results comparable with experimental data obtained at these temperatures. The model therefore adequately describes the threshold characteristics of these lasers with donor concentrations up to 5.10^{18} cm^{-3} or acceptor concentrations up to 2.10^{19} cm^{-3} over the 80-300 K temperature range. The authors thank P.G. Yeliseyev and O.V. Bogdankevich for fruitful discussion. Figures 4; references 24: 16 Russian, 1 Polish, 7 Western (1 in Russian translation).

2415/12232

Electromagnetic Properties of Massive Dirac Neutrino in External Electromagnetic Field

18620134c Tomsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA in Russian Vol 31 No 3, Mar 88 (manuscript received 7 Aug 85) pp 64-70

[Article by A.V. Borisov, V.Ch. Zhukovskiy and A.I. Ternov, Moscow State University imeni M.V. Lomonosov]

[Abstract] Within the framework of the standard Weinberg-Salam theory, a massive Dirac neutrino acquires a nonzero anomalous magnetic moment (AMM). Distinguishing between the contribution to the AMM of the particle's transition to the negative- and positive-frequency intermediate states is important for interpretation of the AMM's sign and for constructing visualizable models of the AMM. This has been done in another study by precisely taking into account the constant and uniform external electric and magnetic fields in the Weinberg-Salam model in a single-loop approximation. The proportion of the contributions of positive- and negative-frequency intermediate states depends essentially on the neutrino's energy. It is demonstrated in the present study that the resultant AMM of a neutrino has a positive sign. A Hamiltonian function is obtained that describes the motion of a neutrino in a weak external field. The radiant intensity of the AMM of a neutrino in a constant magnetic field is computed. The electromagnetic radiation of a neutrino becomes possible because of the neutrino's spontaneous transitions between states differing in the orientation of the AMM. A neutrino's radiation is discussed also according to perturbation theory. It is shown that only a neutrino whose spin is directed counter to the external magnetic field can emit a photon. The emission process is accompanied by a change in the orientation of the neutrino's spin. The behavior of a longitudinally polarized neutrino in an external magnetic field is also discussed. Longitudinal polarization precesses around the direction of the field, whereas transverse polarization can change only with the emission of a photon, with left becoming right. Transverse polarization practically does not change in the process of the propagation of a neutrino in an external field. The change in longitudinal polarization can become an observable effect in a strong magnetic field. Tables 1; references 17: 11 Russian, 6 Western.

8831

Soliton Stability in One Nonlinear Model of Holding of Quarks

18620134b Tomsk IZVESITYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA in Russian Vol 31 No 3, Mar 88 (manuscript received 22 Jul 85) pp 39-44

[Article by N.L. Argiru and Yu.P. Rybakov, University of Friendship of Peoples imeni Patrice Lumumba]

[Abstract] According to the nonlinear mechanism for the holding of quarks, bosons interacting with quarks, because of strong self-force, create for them a holding potential of the "soliton bag" type. A model illustrating this mechanism has been suggested, in which quarks and bosons are described by combined and effective scalar fields, respectively. A one-dimensional version of a similar model that finds soliton and kink solutions to the field equations describing the coherent states of quarks and bosons has also been suggested. The nonlinear mechanism for the holding of quarks is effective only on the condition that the solitons are stable. Soliton stability has been studied by numerical methods, but here the stability of solitons in the one-dimensional version of the scalar model of a "soliton bag" is studied by employing the Lyapunov stability criterion. The range of variation of the model's parameters is found, in which the nodeless soliton solution is stable in Lyapunov's sense and the corresponding quark holding mechanism is effective. The limitations are found on parameters g and v of the model's Lagrangian density. The soliton is provided with mass and a charge and the stability of the stationary soliton solution to the field equation is studied with respect to initial perturbations with a fixed charge. The soliton is considered perturbed if it is described by fields not belonging to the orbit of this solution. The region of stability in parameter plane v, g is shown graphically, illustrating the region in which the quark holding mechanism described by the model is effective. Figures 1; references 11: 5 Russian, 6 Western.

8831

Neutrino Emission From Supercritical Quasi-Atom

18620134a Tomsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA in Russian Vol 31 No 3, Mar 88 (manuscript received 1 Jul 85) pp 16-21

[Article by V.V. Lasukov, Tomsk Polytechnical Institute imeni S.M. Kirov]

[Abstract] The production in the laboratory of strong electromagnetic fields with the collision of intense beams of charged particles and work on x-ray and gamma-ray lasers are opening up opportunities for observing various quantum effects in a strong external field. It was found in experiments that in certain single crystals electric fields exist whose strength can reach 10^{12} V/cm so that in relation to relativistic electrons with energy of 10 GeV, that perform undulatory motion in a strong external field, the field's effect will be equivalent to the effect of a supercritical field with a strength of 1.32×10^{16} V/cm. Since its transverse motion is finite and quantized and its longitudinal motion along the crystallographic line assigned is free, then a relativistic particle moving along the assigned crystallographic line of the single crystal under undulatory conditions is a supercritical quasi-atom that moves steadily at relativistic velocity. A quasi-atom is called such because it differs from a real atom in terms of its size and relativism. From this viewpoint neutrino emission can be generated in spontaneous transitions of particles from the intial state of transverse

motion to the final state resulting in electromagnetic interaction. The fact that the quasi-atom moves at relativistic velocity, combined with the Doppler effect, results in the fact that the neutrino emission orginating is of sufficient intensity for experimental detection. One of the most interesting quantum effects in a strong field is the generation of e^-, e^+ pairs from a vacuum. A theoretical study, based on the Weinberg-Salam theory, is presented of the emission of neutrino pairs by a supercritical quasi-atom. It is assumed that a relativistic electron moves along the atomic plane of a single crystal at a narrow angle. The particle's longitudinal motion is relativistic and can be considered free since the longitudinal force accelerates more slowly than the transverse by a factor of the square of the Lorentz factor. Axis z is directed along the atomic plane and axis x perpendicular to it. Transverse motion along axis x is performed in an electric field averaged for directions z and y of the single crystal's atomic plane. The transverse motion is finite and quantized and the particle moves along a path that is on the whole close to a straight line. In other words, it performs undulatory motion. A particle performing this kind of motion can be interpreted as a "unidimensional" quasi-atom moving with relativistic velocity. The emission of neutrino pairs will be generated in spontaneous transitions between states of transverse motion performed on account of weak interaction. Expressions are obtained for the sum probability of neutrino emission for all transitions, and for the total yield of neutrino emission. References 8: 7 Russian, 1 Western.

8831

Functions Characterizing Fragmentation of Quark-Gluon Systems

18620139a Moscow YADERNAYA FIZIKA in Russian Vol 47 No 1, Jan 88 (manuscript received 8 Sep 86) pp 220-229

[Article by R.G. Vadalyan, Yerevan Institute of Physics]

[Abstract] Soft fragmentation of a quark-hadron system into a hadron, a multi-particle process, is analyzed in statistical terms. Such a system consisting, in a system of infinite momentum, of valence quarks and sea patrons is described by their distribution functions with respect to the Feynman variable in accordance with the Kuti-Weisskopf model. Quark-gluon Fragmentation functions are derived and evaluated on this basis, for fragmentation of a hadron H quark-gluon system into a hadron h with attendant hadron-hadron interaction according to the multiparton recombination model and for fragmentation of a quark-gluon system which has been formed by evolution of a quark. the results of theoretical calculations are compared with experimental data on the distribution of multi-parton subsystems in a pi-meson and on the pi^{plus}/pi^{minus} (pi^{minus}/pi^{plus}) yield ratio in highly inelastic neutrino-proton or antineutrino-proton interaction. Figures 3; tables 1; references 24: 6 Russian, 18 Western.

2415/12232

Low-Energy Fission of Au-Nuclei by Protons and Alpha-Particles

18620139b Moscow YADERNAYA FIZIKA in Russian Vol 47 No 1, Jan 88 (manuscript received 4 Jan 87) pp 7-15

[Article by M.G. Itkis, N.A. Kondratyev, Yu.V. Kotlov, S.I. Mulgin, V.N. Okolovich, A.Ya. Rusanov, Institute of Nuclear Physics, KaSSR Academy of Sciences, and G.N. Smirenkin, Institute of Physics and Power engineering, Obninsk]

[Abstract] In an experiment concerning symmetric fission of cold nuclei with A number Z lower than 89, such an experiment being difficult to perform owing to their small cross-section, it was possible to monitor the fission of ^{201}Tl and ^{198}Hg nuclei in ^{197}Au(p,f) and ^{197}Au(alpha,f) reactions with the excitation energy at the saddle point within the 10-15 MeV range and thus above the threshold level but much lower than in previous experiments. As target was used a 0.150-0.200 mg/cm^2 thick, thicker than before but still sufficiently homogeneous, self-sustaining Au-foil. Measurements were made with a pair-effect energy spectrometer of fission fragments using a Si(Au)-detector, high-speed and high-(time) resolution electronic circuitry minimizing the background noise from scattered particles. These measurements, with the excitation energy at the saddle point 14.7 MeV or 10.6 MeV for ^{201}Tl and 14.9 MeV for ^{198}Hg, have yielded the dependence of mass yield Y and of total kinetic energy E_k as well as of its dispersion s_E^2 on the mass M of the heavy fragment. The thus obtained distributions &(M) and E_k(M) differ from those according to the liquid-drop model, Y(M) deviating from a Gaussian one and E_k(M) differ from those according to the liquid-drop model, Y(M) deviating from a Gaussian one and E_k(M) deviating from a parabolic one. The authors thank Ye.N. Gruzintsev and V.N.Tolstikov for assisting in measurements. Figures 5; tables 1; references 13: 7 Russian, 6 Western.

2415/12232

Phase Conjugation in Field of Surface Reference Waves

18620053b Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 63 No 3, Sep 87 (manuscript received 11 Nov 86) pp 575-578

[Article by G.V. Arutyunyan and G.P. Dzhomyan]

[Abstract] A nonlinear four-wave parametric process in the field of two counter-propagating electromagnetic surface waves at the boundary between a nonlinear isotropic medium and a linear one is considered, namely interaction also involving an obliquely incident plane electromagnetic signal wave and the counter-propagating phase-conjugate one as well as the Fresnel-reflected one. Degenerate interaction with a high conversion ratio, all waves having the same frequency, is analyzed on the basis of applicable equations for the electric field components in both media. Their solution indicates that either of those two waves can be completely suppressed by regulation of pump intensity, wavelength, or incidence angle. Theoretical results are supplemented with numerical estimates. Figures 1; references 6: all Western.

2415/9604

Tolerance of Radial Shift of Object in Adaptive Optical Systems

18620053c Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 63 No 3, Sep 87 (manuscript received 26 Jul 86) pp 616-618

[Article by V.V. Kleymenov and Ye.V. Novikova]

[Abstract] Correction of wavefront aberrations in an adaptive optical system is shown to require correction of the wavefront slope only, assuming that the phase shift will vanish in operation. For the purpose of facilitating design of such a system with subapertures controlled in the relay mode during axial movement of the object, an algebraic expression is derived for the Sterli coefficient as a function of its radial shift. On this basis it is possible to calculate the tolerance on the radial shift in any specific situation with given numerical data. Figures 2; references 4: 1 Russian, 3 Western (1 in Russian translation).

2415/9604

Recovering Polarization of Light in Multimode Optical Fibers by Means of Holographic Phase Conjugation

18620056 Leningrad PISMA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 13 No 19, 12 Oct 87 (manuscript received 23 Jun 87) pp 1153-1158

[Article by V.M. Zaporozhets, F.N. Marchevskiy, and V.L. Strizhevskiy, Kiev State University imeni T.G. Shevchenko]

[Abstract] Holographic phase conjugation of a light wave during its reflection at the end of a multimode optical fiber is proposed as a way to recover its polarization after it has been depolarized as a result of scattering by volumetric and surface inhomogeneities along the fiber, the feasibility of correcting the distorted wavefront by this method having been considered in an earlier study. Analysis of the mechanism is based on propagation of an electric field through a multimode fiber segment, with the electric field resolved into m polarization-degenerate modes and N modes with identical polarization but different spatial distributions. In the Jones formalism transmission of a field along such a fiber is equivalent to linear transformation of amplitudes with the aid of a 2N-dimensional matrix. The theoretically established feasibility of this method has been confirmed experimentally on a fiber consisting of a 0.2 mm thick quartz core and a polymer sheath. The experiment was performed with an LG-38 He-Ne laser, two beam-splitter cubes, an Ahren's prism between them, an analyzer, a fiber segment between two microobjectives, refractive $LiNbO_3$:(0.03-0.07 percent Fe) crystals as holographic medium, two plane mirrors, an adjustable delay line between the first beamsplitter and the first mirror, and a recording instrument preceded by a diaphragm behind the second beamsplitter. Figures 3; references 7: 4 Russian, 3 Western.

2415/9604

New Phenomena in Quantum Optics: Antibunching and Sub-Poissonian Statistics of Photons, Squeezed States of Radiation Field

18620049 Moscow USPEKHI FIZICHESKIKH NAUK in Russian Vol 153 No 2, Oct 87 pp 233-271

[Article by D.F. Smirnov and A.S. Troshin, Leningrad State Pedagogical Institute imeni A.I. Gertsen]

[Abstract] Characteristics of the photocurrent correlation function and the light intensity fluctuation spectrum, both measurable, reveal antibunching and sub-Poissonian phonon statistics as well as squeezed states of the radiation field and their relation to those statistics in accordance with basic concepts of quantum optics. A mechanism fundamental to quantum theory of radiation and such an interpretation of these phenomena is nonlinear resonant fluorescence of noninteracting atoms. An analysis of this mechanism has been based on group expansion of correlation functions, aided by probability theory and theory of random processes. Antibunching of photons generated by fluorescence of a single atom is considered first, polyatomic effects are then added for a complete interpretation of this phenomenon. Most interesting squeezed states of the radiation field are two-photon coherent states, realizable with sources such as a degenerate parametric amplifier or a four-wave mixer. Other mechanisms which lead to antibunching and sub-Poissonian phonon statistics are luminescence of atoms in an array with repulsive interaction statistics, such luminescence being excitable by an electron beam with suppression of Schottky noise, and luminescence of impurity centers in crystals as a result of cooperative

quenching. A promising source of radiation with sub-Poissonian phonon statistics is a laser. Suppression of light intensity fluctuations to sub-Poissonian level and resulting emphasis of the regular light intensity component can evidently be achieved by regular pumping, which has been demonstrated by inclusion of pumping statistics in the theory of single-mode radiation emission. A scheme for regular periodic-pulse pumping is possible, major problems being the randomness of the decay of state "2" and the repulsive pumping statistics. Under consideration are lasers with m-photon useful transitions and n-photon losses, the simplest laser being one with 1-photon useful transition and 2-photon losses. Such lasers need to be optimized for maximum manifestation of sub-Poissonian statistics. The authors thank S.A. Akhmanov for recommending a review of this subject and for many useful suggestions, Ye.B. Aleksandrov, Yu.M. Golubev, V.V. Ovsyankin, I.V. Sokolov, Ye.D. Trifonov, A.S. Chirkin, V.L. Shekhtman for stimulating discussions, and I.I. Katanayev for assistance in writing this review. Figures 23; references 228: 80 Russian, 148 Western (23 in Russian translation).

2415/9604

Investigation of Titanium-Beryllium Multilayer Roentgen Reflectors Produced by the Method of Electron-Beam Deposition

18620201 Leningrad PISMA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 13 No 3, 12 Feb 87 (manuscript received 9 Oct 86) pp 129-132

[Article by A.V. Vinogradov, I.V. Kozhevnikov, V.V. Kondratenko, I.I. Lyakhovskaya, A.T. Ponomarenko, Physics Institute imeni P.N. Lebedov, Academy of Sciences, USSR, Moscow]

[Abstract] The article investigates the reflectivity of multilayer reflectors consisting of layers of titanium and beryllium. The reflectors were produced by the method of successive electron-beam deposition of titanium and beryllium on a glass substrate. Synthesis of the reflector was performed under a vacuum of 10^{-5}—10^{-6} mm of mercury. Electron-beam deposition made it possible to assure a satisfactorily high quality of multilayer structures with beryllium. The measured value of the reflectance at a maximum is closed to that calculated. In principle the multilayer reflector with beryllium can be used in two spectral ranges: gl [is less than] 4.4 mm and gl [is less than] 11.3 nanometer. The authors thank I.A. Zhitnik for helpful discussions. Figures 2; references 11: 5 Russian.

6415/9604

Holographic System for Visualization of Sections Through Phase Nonuniformities

18620163 Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 46 No 2, Feb 87 (manuscript received 21 Oct 85) pp 295-301

[Article by Ye.M. Platonov]

[Abstract] A holographic system is proposed for sharp focusing by means of a lenticular raster, capable of recording holograms with high diffraction efficiency and minimum focusing depth for a given aperture of the illuminated object. A collimated object beam illuminates a square lenticular raster so that in the focal plane of the latter, coinciding with the focal plane of the condenser lens, there forms a two-dimensional raster pattern of images of a point source. The optical components are designed for maximum utilization of raster elements and avoidance of stray losses, namely with l/f [less than or equal to] (D-L)/(F-f) (l,f - dimension and focal length of a raster element, L - dimension of raster, D,F - diameter and focal length of condenser lens). The performance of this system is demonstrated on a phase nonuniformity and its shadow images, for which case the dependence of image visibility on the number of raster elements N (number of illuminating beams) and the depth of focusing as well as on the image luminance and the background luminance is established. The focusing depth is, in turn, proportional to the ratio F/L (L = N1). The system was tested on a supersonic gas stream flowing past two parallel blunt cylinders inside a wind tunnel and on visualization of the compression shock before one of them. With sharp focusing on one of the cylinders, the other cylinder and the compression shock before it appeared blurry. Focusing by means of a lenticular raster and recording object waves without their superposition is found to be more advantageous than focusing by means of a diffraction grating. Figures 4; references 6: 4 Russian, 2 Western.

2415/9604

Including Optical Characteristics of Surface Layer in Determination of Reflection Coefficient and Transmission Coefficient of Transparent Dielectric Materials

18620163 Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 46 No 2, Feb 87 (manuscript received 29 Oct 85) pp 272-279

[Article by I.A. Khramtsovskiy, V.I. Pshenitsyn, G.I. Kadaner, and A.V. Kislov]

[Abstract] Both forward and inverse problems of ellipsometry for a surface layer of a transparent dielectric material are solved, for the purpose of including the optical characteristics of this layer in determination of the reflection coefficient and the transmission coefficient. The approximation of a homogenous surface layer

not always being adequate, the model of a nonhomogeneous surface layer comprising a stack of thin homogeneous ones is considered instead and its interaction with a plane incident electromagnetic wave is described by the Abellian recurrence relations. The medium from which the wave enters the dielectric material is assumed to be transparent with a refractive index n_1 and the refractive index n= n(z) of the surface layer is assumed to reach a constant value n_0 at depth z[leads to]oo below the surface. The correction gdR_j for the j-th layer of thickness gDz_j to the reflection coefficient R_0 and the deviation gDu_j due to this layer from the bulk admittance u_0 are calculated according to the principle of fictitious successive removal of each j-th layer from below, beginning either at the substrate or at infinity. An equation is obtained on this basis which relates the measured ellipsometric parameter gr= e^{igD}tangf and the optical characteristics of the surface layer. The refractive index and the thickness of the surface layer are then found by evaluation of the product of two semiinfinite integrals with an upper bound selected on the basis of the permissible error. In an experiment with 1 mm thick and 40x40 mm^2 large plates of polished optical glasses KI, LK3, K8, TF10, measurements were made with an LEF-2 ellipsometer in light of the gl = 632.8 nm wavelength incident at 50°, 55°, 60°, 70° angles. The transmission coefficient was measured at normal incidence of gl = 532 nm radiation and gl = 1064 nm radiation. The results of calculations and measurements agree closely enough to validate this practical method of accounting for losses in the surface layer on the basis of ellipsometric gD and gf readings. Figures 1; tables 2; references 10: 7 Russian, 3 Western (2 in Russian translation).

2415/9604

Scattering of Light by Scleral Shell of Human Eye

18620162 Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 46 No 1, Jan 87 (manuscript received 19 Aug 85) pp 104-107

[Article by V.V. Bakutkin, I.L. Maksimova, P.I. Saprykin, V.V. Tuchin, and L.P. Shubochkin]

[Abstract] Transmission of light by the sclera of the human eye is analyzed, this turbid semiopaque part of the eye consisting essentially of collagenous fibers immersed in an isotropic basal substance with a random orientation but all parallel to the outer surface. Since the diameter of these fibers is comparable with the wavelengths of visible light, 20-300 nm, the transmission spectrum of the sclera is calculated on the basis of its light scattering characteristics not in the Rayleigh approximation but by rigorous solution of the corresponding Maxwell field equations for boundary conditions at a cylindrical surface analogous to the equations of the Mie theory of scattering by a spherical surface. A simple relation between the transmission coefficient and the cross-section for scattering is established, assuming a gamma distribution of fiber diameters and taking into account loss of light due to Fresnel reflection at the boundary between air and the isotropic basal substance. The results of numerical integration using available data on optical properties and structural characteristics of the sclera agree fairly well with spectrophotometer readings taken in a standard experiment with the sclera excised from a corpse. The results of further experiments with 76 percent verographin solution added to the natural basal substance indicate the feasibility of temporarily clearing and thus controlling the sclera. Figures 1; references 15: 9 Russian, 6 Western (3 in Russian translation).

2415/9604

Probing of Collective Excitation States Induced by Stimulated Scattering With Phase Conjugation

18620165 Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 51 No 2, Feb 87 pp 362-366

[Article by V.I. Kislenko, V.S. Ovechko, and V.L. Strizhevskiy, Kiev State University imeni T.G. Shevchenko]

[Abstract] Two methods of probing with pulses the space-time distribution of collective excitation states induced by stimulated scattering with phase conjugation are proposed and theoretically evaluated on the basis of equations describing the respective mechanisms. The method of "self-probing" with a pulse of the scattered radiation involves formation of a Stokes wave by stimulated scattering of a light wave by fluctuations of the refractive index. It is practical and simple, as demonstrated in an experiment, especially with efficient pulse compression. Probing with a pulse of second-harmonic pump radiation is particularly applicable to a hypersonic wave induced by stimulated Mandelshtam-Brillouin scattering, such a wave containing information on the pump wave when scattering is accompanied by phase conjugation as well as on the Stokes wave dynamics. The parameters of a probing pulse reflected by such a hypersonic wave are calculated for a probing light beam at an angle to the pumping radiation beam corresponding to Bragg reflection. This method was implemented with a YAG:Nd^{3+} laser and a SMBS (stimulated Mandelshtam-Brillouin scattering) generator-amplifier system using acetone as the nonlinear medium. Figures 5; references 10: 8 Russian, 2 Western (1 in Russian translation).

2415/9604

Phase Conjugation by Vector Self-Diffraction on Polarization Holograms

18620165 Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 51 No 2, Feb 87 pp 307-310

[Article by A.A. Borshch, N.V. Kukhtarev, and V.N. Semioshko, Institute of Physics, UkSSR Academy of Sciences]

[Abstract] A theory of vector self-diffraction by anisotropic linear absorption of light in a nonlinearly polarizable semiconductor is constructed, to establish the feasibility

of phase conjugation by this mechanism. Absorption of a single light quantum entering at some velocity is considered, free charge carriers being generated as a result and their concentration at any subsequent instant of time depending on their diffusion and recombination rates in accordance with the corresponding kinetic equation. Appearance of free charge carriers changes the polarizability of the medium in the electric field of the incident light wave, owing to their band-to-band transitions at some frequency not necessarily equal to the resonance frequency. The theory has been confirmed experimentally by recording of holograms in a CdS crystal within its anisotropy range of linear absorption with second-harmonic radiation of a Q-switched glass (phosphate): Nd^{3+} laser (gl = 0.532 gmm wavelength). The linearly polarized light beam was split by means of a birefringent calcite crystal (Iceland spar) into two orthogonally polarized light beams of equal intensities. An analysis of the self-diffraction pattern recorded on a holographic grating in the CdS crystal reveals symmetric non-Braggian diffraction orders with orthogonal polarizations, each polarization coinciding with the preferential polarization of the nearest transmitted zeroth-order light beam. Such a vector hologram is characterized by a diffraction efficiency which varies sinusoidally between zero and maximum as a function of the angle between the polarization axis of one of the recording light beams, say the one with vertical polarization, and the optical axis of nonlinearity anisotropy in the crystal. It is zero when that angle is 0°(180°) or 90° and maximum when that angle is 45° or 135°. The intensity I_{112} of the first non-Braggian order was found to depend quadratically on intensity I_{10} of the nearer recording light beam and linearly on intensity I_{20} of the farther recording light beam. Figures 4; references 3: 2 Russian, 1 Western.

2415/9604

Methods and Schemes of Phase Conjugation for Middle-Infrared Radiation

18620165 Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian
Vol 51, No 2, Feb 87 pp 299-306

[Article by A.A. Betin and V.Ye. Sherstobitov, Institute of Applied Physics, USSR Academy of Sciences]

[Abstract] Available experimental data on phase conjugation of CO_2-laser radiation pulses of submicrosecond to centosecond duration by four-wave interaction and by four-wave interaction with feedback in nonlinear liquid or gaseous media are reviewed and evaluated, including data on generation of sufficiently strong pump waves with adequate characteristics for this purpose. Experiments were performed with pulsed electroionization and photoionization CO_2-lasers tunable over rotational lines, using SF_6 as buffer gas and conventional mirrors and plates made of transparent materials for polarization decoupling. Most successful as nonlinear media for phase conjugating four-wave interaction mirrors were found to be liquid CCl_4 and compressed gaseous Xe. Wavefront self-reversal by four-wave mixing with feedback was achieved using a self-pumping mirror, a beam widening telescope, a pulse amplifying auxiliary photoionization CO_2-laser, and a NaCl, ZnSe, or Ge plate oriented at the Brewster angle to the laser beam between the cell with nonlinear medium and the telescope. It was also achieved with continuous-wave CO_2-laser and Fourier phase correlator. Figures 5; references 15: 14 Russian, 1 Western.

2415/9604

Phase Conjugation by Multiwave Parametric Mixing in Resonant Media

18620165 Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian
Vol 51 No 2, Feb 87 pp 270-279

[Article by P.A. Apanasevich, A.A. Afanasyev, and B.A. Samson, Institute of Physics, BSSR Academy of Sciences]

[Abstract] A theory of phase conjugation by multiwave parametric mixing is presented, namely by six-wave mixing in the field of two oppositely propagating collinear strong pump waves. Interference of any of them and a weak probe wave propagating at some angle to it induces dynamic lattices in a nonlinear medium and Bragg diffraction of both pump waves by these lattices so that a backward weak wave with reversed wavefront is generated, while Bragg diffraction of the probe wave generates another weak forward wave which propagates at an angle symmetrically to the probe wave and also subject to phase conjugation. A mathematical model of this parametric process is constructed in the two-level approximation for a resonant medium with nonlinear polarization and uniform broadening of the absorption line. In a spacewise modulated field of strong pump waves this polarization is a fast-oscillating function of the longitudinal coordinate. A system of two pairs of coupled equations for the amplitudes of four weak waves and their profiles in the field of two strong waves, assuming no absorption of the latter, is derived by standard averaging and extraction of polarization harmonics. This model is used for analysis of six-wave mixing without and with frequency degeneration. In the case of incidence angles of the signal wave much larger than that corresponding to exact phase synchronism of diffractions there is no second weak wave produced and the process reduces to four-wave mixing, without or with frequency degeneration. For each case are evaluated spectral and energy characteristics of phase-conjugated radiation as well as dependence of the reflection coefficient and the critical medium length for nonlinear interaction on the incidence angle of the weak signal wave, also the effect which power asymmetry of the pump waves has on the spectrum of weak waves. Figures 6; references 20: 11 Russian, 9 Western.

2415/9604

Examination of Optical Surfaces Under Scanning Tunnel Microscope

18620118a Leningrad PISMA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 14 No 3, 12 Feb 88 (manuscript received 27 Nov 87) pp 256-259

[Article by V.K. Adamchuk, V.M. Aleksandrov, A.V. Yermakov, and I.V. Lyubinetskiy, Scientific Research Institute of Nuclear Physics, Leningrad State University imeni A.A. Zhdanov]

[Abstract] A new scanning tunnel microscope was built and used for nondestructive topographical examination of metallized optical surfaces. The absence of any mechanical contact with the surface is one major advantage of such microscopes. Another advantage is the 1 nm or better resolution under standard atmospheric conditions; only a 100 nm resolution on a surface mechanically polished with a diamond needle being attainable under an optical microscope. Electron energy in this microscope is low, varying from several meV to several eV. Large surfaces, up to 0.010x0.010 mm^2, can be examined in one scan within 3 s. The needle electrode is moved mechanically toward the surface from a distance of several mm with 50 nm precision. The manipulator which moves the needle also parallel to the surface maintaining a constant gap width for tunneling consists of three mutually orthogonal piezoelectric transducers made of PKR-6 or PKR-7M ceramic. Sensitivity of their drives is 18 nm/V parallel to the surface and 3nm/V normal to it. Figures 2; references 6: 3 Russian, 3 Western.

Use of Gires-Tournois Interferometer for Extracavity Compression of Femtosecond Light Pulses

18620118b Leningrad PISMA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 14 No 3, 12 Feb 88 (manuscript received 13 Aug 87) pp 276-279

[Article by R.A. Timofeyev and G.B. Tolstorozhev, Institute of Physics, BSSR Academy of Sciences, Minsk]

[Abstract] A specially designed Gires-Tournois interferometer was used for compressing femtosecond light pulses from a dye laser outside the cavity. The interferometer is a modification of the Fabry-Perot standard, its front surface having a 100 percent reflection coefficient and its back surface having a less than 100 percent reflection coefficient. Time delay is produced here by multiple interference of mutually phase-delaying reflected wave groups, rather than by angular dispersion, during either refraction or diffraction within the plate lattice. The dye laser (610-630 nm), rhodamine 6G in ethylene-glycol solution, operated with combination active and passive mode locking. It was pumped synchronously by a quasi-continuous train containing pulses of 80-150 ps duration and with 450 MW average power at a repetition rate of 76 MHz. A jet of saturating absorbent, DODCI in ethylene-glycol solution, was pumped through a supplementary focusing space inside the cavity for additional passive mode locking. Measurements were made by the autocorrelation method with noncollinear second-harmonic generation in a KDP crystal. Emission pulses of 710 fs duration and with a 5 kW peak power were extracted at a repetition rate of 5 MHz. Figures 2; references 9: all Western.

02415/09599

Multimode Cooperative Raman Scattering

18620109a Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 64 No 2, Feb 88 (manuscript received 2 Mar 87) pp 269-273

[Article by Yu.A. Ilinskiy and A.S. Mkoyan]

[Abstract] Multimode cooperative Raman scattering is analyzed from the quantum theoretical standpoint and corresponding equations are derived which describe this process, in a long cylindrical vessel containing two-level atoms longitudinally excited by a pumping step pulse. Assuming an initially noncoherent state of the medium, multimode cooperative scattering by components of both Stokes and anti-Stokes fields is considered with attendant interaction with the thermostat as well as with subsequent induced processes and four-wave parametric interaction. Following solution of the equation of motion for the density matrix with the interaction Hamiltonian, coefficients of correlation between the various scattering modes are calculated by replacement of summation over all atoms and summation over all modes with respective integrations. Numerical results are shown which reveal the effect of departure from space co-phasality. Figures 2; references 6: all Russian.

Low-Temperature Fluorescence Spectra of Anthracene Absorbed by Silica Surface Upon Selective Excitation by Laser Radiation

18620109b Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 64 No 2, Feb 88 (manuscript received 17 Mar 87) pp 320-324

[Article by L.A. Bykovskaya, S.G. Kulikov, A.M. Yeremenko, and V.N. Yankovich]

[Abstract] Physical absorption of the aromatic compound anthracene by surfaces of very pure and fairly homogeneous silicas, nonporous aerosil and porous silica gel, upon its selective excitation by laser radiation at 4.2 K temperature was studied in an experiment, anthracene in n-hexane being excited by ultraviolet light of 374.1 nm wavelength from a tunable RVD-dye laser with a power density of about 0.2 mW/cm^2. This laser was pumped with radiation from a N_2-laser in pulses at a repetition rate of 12 Hz. The emission line of the dye laser was about 0.1 nm wide. Both silicas had been, prior to absorption, heat treated at 300, 500, 800 deg C. The fluorescence spectra of 10^{-5}-10^{-2} monolayer thick

absorbed anthracene was measured in an SDL-1 spectrometer with 0.08 nm resolution. These spectra are compared with those of anthracene absorbed from an isooctane plus methylcyclohexane upon excitation by ultraviolet light of 337.1 nm wavelength from a wideband laser or other source. Selective excitation is found to result in a fluorescence spectrum with narrow peaks indicating its nonuniform broadening and presence of phononless lines in it. The authors thank R.I. Personov for helpful discussion. Figures 3; tables 1; references 12: 9 Russian, 3 Western (1 in Russian translation).

Shape and Spectrum of Pulses of Resonant Raman Light Scattering and of Other Components in Secondary Emission by Polyatomic Molecules, Part 2: Accounting for Nonradiative Transitions and Considering Specific Pulse Transformations

18620109c Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 64 No 2, Feb 88 (manuscript received 24 Mar 87) pp 336-342

[Article by V.A. Morozov and P.P. Shorygin]

[Abstract] Resonant Raman light scattering by polyatomic molecules and other components of secondary emission, namely Rayleigh scattering and luminescence as well as hot luminescence, are analyzed taking into account not only radiative intermediate transitions in such molecules but also nonradiative ones as well as photochemical dissociative transitions from intermediate states to continuous-spectrum states and phonoic transitions. The resulting pulse shape and spectrum transformation is described, considering specifically a short incident pulse of duration much shorter than the lifetimes of all excited states but longer than the T_{43} period, then a long incident pulse, and also a sinusoidal incident pulse of intermediate duration. Calculations reveal that Raman scattering pulses and Rayleigh scattering pulses have identical shapes but different spectra, the pulse shape of all Raman scattering components coinciding with the changing population of levels in a molecule as function of time and spontaneous emission by a molecule occurring from a state which is finite for Raman scattering. The shape of luminescence and hot luminescence pulses is found to be in each case different than the shape of Raman scattering pulses, which facilitates extraction of the latter from background-noise luminescence. References 12: 10 Russian, 2 Western.

Nature of Background Radiation in Raman Scattering Spectra of Anthracene Single Crystals

18620109d Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 64 No 2, Feb 88 (manuscript received 16 Feb 87) pp 360-365

[Article by V.A. Lisovenko, G.A. Sandul, and M.T. Shpak]

[Abstract] An experimental study concerning background radiation in Raman scattering spectra was made, for the purpose of determining its nature in the specific case of anthracene single crystals with already well-known luminescence characteristics. Single crystals 0.010-0.100 mm thick were grown by the sublimation process and up to 0.5 cm thick ones were grown from the melt. All single crystals were excited with radiation of the 441.6 nm wavelength from a He-Cd laser at temperatures of 4.2 K, 77 K, 300 K, and above room temperature, whereupon their Raman spectra were recorded in a DFS-12 spectrometer as well as by the photoelectric method through an SPM-2 monochromator at 90 deg to the direction of the laser beam. These spectra and the temperature dependence of the background radiation intensity, the logarithm of the latter decreasing almost linearly with increasing inverse of the temperature, indicate that in this particular case the background radiation is produced by exciton luminescence at low temperatures as well as at room temperature. The mechanism of exciton luminescence at low temperatures and thus not subject to Boltzmann's law is, however, a different one: triplet excitation with subsequent triplet-triplet annihilation more likely than two-photon absorption. A definitive determination could not be made, owing to the very low luminescence intensity in the Raman spectrum of thin crystals and to complete disappearance of background radiation from the Raman spectrum of thick crystals at 4.2 K temperature. Absence of background radiation explained by imperfection of large crystals with defects acting as traps for triplet excitons and thus preventing triplet-triplet annihilation. Figures 3; tables 1; references 10: 3 Russian, 7 Western.

Duration of Picosecond Pulses Generated by Self-Conversion of Laser Radiation Through Stimulated Raman Scattering

18620109e Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 64 No 2, Feb 88 (manuscript received 23 Mar 87) pp 397-401

[Article by K. Andryunas, A. Barila, Yu. Vishchakas, I.V. Mochalov, G.T. Petrovskiy, and V. Syrus]

[Abstract] An experimental study of stimulated Raman scattering in $KGd(WO_4)_2$:Nd^{3plus} and $KY(WO_4)_2$:Nd^{3plus} crystals for intracavity self-conversion of laser radiation into ultrashort pulses was made, the object being to determine the dependence of their duration on the efficiency of energy conversion and thus the feasibility of controlling it. A crystal serving as active medium of a Nd^{3plus}-laser was placed in a 1.3 m long cavity between a high-reflectance mirror and a glass substrate, the reflection coefficient of the mirror being 0.9994, 0.726, 0.571 for radiation of wavelengths 1060 nm (fundamental of the Nd^{3plus}-laser), 1180 nm (first Stokes component), 1320 nm (second Stokes component) respectively. A 0.6 mm thick layer of 3274u dye solution in ethanol pumped through a sphenoidal cuvette touching the mirror served as shutter. The duration of single pulses was measured with FD-7G photodiodes through an MDR-4 monochromator and also estimated on the basis of the autocorrelation function, the latter having been obtained with

noncollinear sec ond-harmonic generation and precedence of the pulse extracted from a train being monitored with a coaxial FK-26 photoreceiver as well as on an S7-19 high-speed oscillograph. Dispersive optics served as spectral radiation selector. The energy conversion ratio was measured with a prism consisting of TiO_2 crystals. Pulse duration measurements were made with the second crystal serving as amplifier either optically pumped (active amplification) or not (passive amplification). The results indicate the feasibility of converting emission of a Nd^{3plus}-laser into 2.7-12 ps pulses of the fundamental component and 0.9-6.0 ps pulses of the first Stokes component, their duration being controllable by prioritization of the pulse to be extracted with or without regulation of the amplifier pumping. Figures 3; references 6: all Russian.

Calculation of Parameters of Scattered-Light Pulses Recorded in Laser-Type Fiber Analyzers for Determination of Fiber Diameter

18620109f Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 64 No 2, Feb 88 (manuscript received 16 Jun 86) pp 402-406

[Article by V.I. Ovod]

[Abstract] For the purpose of calibration of laser-type scanning microfiber analyzers operating in either the pulse amplitude mode or the pulse energy mode, so as to improve the quality control with respect to fiber diameter, theoretical formulas are derived expressing the amplitude and the energy of light pulses scattered by the fiber into the photodetector aperture as functions of the fiber diameter. These formulas apply to the conventional analyzer geometry, with a straight cylindrical fiber at right angles to the impinging laser beam. They are based on cylindrical scattering and on the proportionality of the luminous flux received by the photodetector aperture to the laser radiation intensity, to the fiber cross-section for scattering per unit area (effective fiber width) in accordance with the precise Mie theory, and to the length of the illuminated fiber segment. Nonuniformity of the fiber illumination is taken into account by use of the mean luminous flux density. Three analyzer variants are considered, with the two edges of the rectangular photodetector aperture seen at angle of 25 and 65 degrees, 8 and 22 degrees, 0.4 and 2 degrees respectively from the origin of the cylindrical system of coordinates. Fibers with the complex refractive index 1.2 -j0.01 (weakly absorbing polymers), 1.59- j0.66 (carbonaceous materials), 1.7- j1.84 (iron), 5- j5 (any strongly absorbing material) for light of the 632.8 nm wavelength are considered. The dependent of the relative scattering cross-section on the fiber diameter over the 0.005-0.120 mm range (linear for first and second analyzer variants, oscillatory for third analyzer variant with oscillatory scattering indicatrix) and the dependence of the photodetector reading (scattered-pulse amplitude) on the angle between the E-polarization plane of laser radiation and the fiber axis over the 0-90 deg range according to calculations have been checked against histograms of fiber inspection readings in the third analyzer, with the fiber mounted in a vertical frame oscillating at a frequency of 50 Hz across the horizontal laser beam. The results indicate that calibration curves with large slopes and thus high sensitivity of such analyzers are attainable. Figures 3; references 12: 8 Russian, 4 Western (1 in Russian translation).

Evaluation of Asymptotic Expressions for Light-Scattering Cross-Section of Rayleigh-Gans-Debye Particles

18620109g Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 64 No 2, Feb 88 (manuscript received 2 Feb 87) pp 426-428

[Article by V.N. Lopashin]

[Abstract] Description of light scattering by a suspension of "soft" particles in the Rayleigh-Gans-Debye approximation, on the basis of the interference model with anamalous diffraction, is evaluated for accuracy of asymptotic expressions for the total scattering cross-section of particles of arbitrary shapes and including large ones (product of wave number and characteristic particle dimension much larger than 1). Calculations for large particles by the method of Maxwell field equations for the electric component and by the Wentzel-Kramers-Brillouin method indicate that the latter yields full agreement with the result of integration with respect to the solid angle over a sphere. References 9: 5 Russian, 4 Western (3 in Russian translation).

Optical Ionization, Luminescence, and Conversion of Color Centers in Alpha-Al_2O_3

18620109h Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 64 No 2, Feb 88 (manuscript received 12 May 87) pp 455-457

[Article by V.I. Baryshnikov, Ye.F. Martynovich, L.I. Shchepina, and T.A. Kolesnikova]

[Abstract] An experimental study of F^{plus} color centers in an alpha-Al_2O_3 single crystal was made, their ionization mechanisms being of primary interest together with excitation, and conversion within the 200-700 nm spectral range of existing tunable lasers. Specimens of such a crystal were grown by the Verneuil method and by horizontal oriented crystallization, whereupon color centers were induced in them by neutron bombardment. These centers, their maximum-absorption lines known to be 230 nm, 260 nm and their charged states known to correspond to 305 nm, 360 nm, 450 nm, 580 nm lines, were then optically excited into the 305 nm state with fourth-harmonic radiation of a YAG:Nd^{3plus}-laser (radiation wavelength 266 nm and power density 1 MW/cm^2). An analysis of their absorption and photoluminescence spectra indicates that the mechanism of their optical ionization into the 305 nm state is one-photon absorption with subsequent electron tunneling, their extinction then occurring by two-step optical ionization with transfer of electrons into the conduction

band and also by recombination with electrons including those released upon breakdown of neutral color centers. Figures 1; references 8: 4 Russian, 4 Western.

02415/09599

Evolution of Light Pulses in a Nonlinear Amplifying Medium

18620133c Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in RussianVol 94 No 3, Mar 88(manuscript received 17 Jun 87) pp 174-182

[Article by V.S. Grigor'yan, A.I. Maymistov and Yu.M. Sklyarov, Scientific Research Institute of the Physics of Condensed Media, Yerevan State University]

[Abstract] Numerical experiments are presented on the propagation of pulses in a nonlinear dispersing inverted medium with gain saturation and linear losses. The experiment showed that in an amplifying dispersing medium with Kerr nonlinearity under conditions of gain saturation and linear losses, independently of the initial amplified pulse, a solitary wave is formed whose parameters (energy, shape and length of pulse, etc.) are determined by the gain saturation α and gain β of the amplifying medium. The numerical experiments further confirm the analytic results indicating formation of the solitary wave as a secant pulse in media with slight dispersion of gain in comparison to the inverse length. The effect can be observed in a single-mode fiber light guide activated by neodymium ions. Figures 6, references 5: 4 Russian, 1 Western.

6508

UDC 535.34:553.824

Picosecond Relaxation of Light Absorption by Ruby Upon Excitation by Electron Pulses

18620140f Leningrad OPTIKA I SPECTROSKOPIYA in Russian Vol 64 No 4, Apr 88 (manuscript received 15 Jun 87) pp 954-955

[Article by A.E. Aluker, B.Z. Gorbenko, R.G. Deych, G.S. Dumbadze, and A.D. Talvirskiy]

[Abstract] An experimental study of the short-duration wideband light absorption by a ruby upon its excitation by nanosecond electron pulses was made, subsequent relaxation of the absorption being a similarly transient process attributable to entrapment of charge carriers and their recombination. Ruby specimens were bombarded with 400 KeV electrons in current pulses of 50 ps duration at a temperature of 80 K. Absorption of radiation at wavelengths covering the 450-1000 nm range was recorded through an electron-optical camera with 10 ps time resolution on RF-3 film and was measured by the photometric method with a microdensitometer, data being processed by a microcomputer and the results being displayed by a graph plotter. Electron bombardment had produced electron-hole pairs in ruby with an initial concentration of $(3\text{-}7).10^{16}$ cm^{-3}, based on measurements of the F-center concentration by comparison with a reference Kcl crystal. Their cross-section for absorption of radiation within the peak of the absorption band with a peak about 600 nm was found to reach $(1\text{-}5).10^{-17}$ cm^2 and to correspond to the first peak of the density of states within the conduction band of alpha-Al_2O_3 about 2 eV above its lower boundary. Figures 1; references 4: 1 Russian, 3 Western.

2415/12232

UDC 535.37:548.0

Systematization of Exciton Lines in CuI Luminescence Spectrum

18620140e Leningrad OPTIKA I SPECTROSKOPIYA in Russian Vol 64 No 4, Apr 88 (manuscript received 18 May 87) pp 943-944

[Article by S.G. Stoyukhin, V.A. Nikitenko, and V.G. Kolotilova]

[Abstract] In continuation of studies made by various authors concerning systematization of exciton lines in the luminescence spectrum of CuI single crystals, these authors succeeded in extracting 10 groups of such lines covering the 404-440 nm range of the spectrum upon excitation of a CuI single crystal with a N_2-laser at the 4.2 K helium temperature. The principal lines of each group ($Z_{1,2}$, J_a, J_b, J_c, J_d, J_{A2}-J_{A1} doublet, J_e, J_f) are successively 151 cm^{-1} apart, which corresponds closely to the energy of a longitudinal optic phonon but does not yet definitely indicate the chemical nature of defects causing exciton luminescence in CuI single crystals produced by the hydrothermal processes and found to contain of the order of 0.001 wt.pct Li, Mg, Al, Si, Ca, Cr, Fe with of the order of 0.0001 wt.pct.Ag. Figures 1; tables 1; references 10: 4 Russian, 6 Western (1 in Russian translation).

2415/12232

UDC 535.81

Performance Analysis of Adaptive Optical Systems for Aperture Probing with Simultaneous Angular and Phase Modulation

18620140d Leningrad OPTIKA I SPECTROSKOPIYA in Russian Vol 64 No 4, Apr 88 (manuscript received 14 Jul 87) pp 910-912

[Article by V.V. Kleymenov and Ye.V. Novikova]

[Abstract] The performance of adaptive optical systems for aperture probing with simultaneous modulation of the slope angle and the phase shift of each subaperture is analyzed in terms of total target luminance. The basic expression for that luminance in the form of a Fourier

series covering the contributions of all subapertures is refined by expansion into a Bessel-Fourier series and application of the Airy formula. It then becomes evident that, with synchronous detection, one can separately control the slope and the shift of subapertures while also correcting aberrations of the radiation wavefront, if interaction of slope control and phase control is avoided. References 3: 2 Russian, 1 Western (in Russian translation).

2415/12232

UDC 535.2+534.222.2

Distortion of Wavefront During Passage of Light Beam Through Shock Wave

18620140b Leningrad OPTIKA I SPECTROSKOPIYA in Russian Vol 64 No 4, Apr 88 (manuscript received 15 Jun 87) pp 859-861

[Article by K.K. Boyarskiy, A.P. Galtsev, O.P. Gashkov, and A.V. Shustov]

[Abstract] Propagation of a light beam through a gaseous medium such as air with a nonuniform refractive index along the light path is analyzed, considering the case where the cause of this nonuniformity is not random temperature and pressure fluctuations but rather regular perturbation in the form of shock waves generated by bodies moving through the medium. The light beam is assumed to have initially a plane wavefront and a body is assumed to move through the medium at a supersonic velocity so as to generate a conical shock wave. The wavefront distortion upon passage of the light beam through such a shock wave is evaluated in the eikonal approximation. The applicable equation of the eikonal in vector form resolves, upon projection onto Cartesian coordinates, into a system of three nonlinear second-order differential equations in space derivatives with respect to length of the beam arc. A computer-aided numerical solution by the Runge-Kutta method has yielded typical wavefront distortion profiles, deviation angle and curvature radius, as the light beam crosses the perturbation axis also in the special case of a moving body on the light-beam trajectory. Figures 3; references 5: 4 Russian, 1 Western.

2415/12232

UDC 535.2+621.375.9:535

Propagation of Ultrashort Light Pulses Through Absorbing Resonant Medium

18620140b Leningrad OPTIKA I SPECTROSKOPIYA in Russian Vol 64 No 4, Apr 88 (manuscript received 1 Jun 87) pp 862-868

[Article by V.A. Vasilyev, N.Ya., Kelbert, I.A. Sazonov, and I.A. Chaban]

[Abstract] Propagation of ultrashort light pulses through resonant optical media is reduced to a linear problem of pulse propagation through a medium with a complex dielectric permittivity, considering that the Bloch equations are not applicable to such pulses. The dielectric permittivity is expressed in a form similar to that based on the Lorentz model but with a more precisely described frequency dependence of the absorption coefficient off-resonance. Asymptotic expressions describing the pulseform evolution in space and time, including the pulse precursor and low-frequency oscillations in the pulse tail, are derived with the aid of Fourier transformation into the frequency domain. A delta-function pulse and an ultrashort square pulse are considered, also an ultrashort constant-amplitude high-frequency pulse train. The authors thank I.L. Fabelinskiy, seminar chairman, and other seminar participants for helpful discussions. Figures 5; references 14: 7 Russian, 7 Western (2 in Russian translation).

2415/12232

UDC 535.375

Time-Resolved Spectroscopy of Spontaneous and Coherent Raman Scattering: Picosecond Dynamics of Excited Electron States in Ni-Octaethyl Porphyrin

18620140b Leningrad OPTIKA I SPECTROSKOPIYA in Russian Vol 64 No 4, Apr 88 (manuscript received 8 May 87) pp 770-777

[Article by V.F. Kamalov, V.V. Kvach, N.I. Koroteyev, B.N. Toleutayev, A.Yu. Chikishev, and A.P. Shkurinov]

[Abstract] An experiment with spectroscopy of spontaneous Raman scattering and spectroscopy of coherent Raman scattering, the latter method yielding a much higher (four orders of magnitude) signal-to-noise ratio, was performed for study of excited electron states and their picosecond dynamics in polyatomic molecules. The spectrometer for this experiment was a universal one operating automatically in the photon-count mode, with a tunable YAG:Nd^{3plus} master laser and a tuning rhodamine-6G dye laser synchronously pumped and emitting picosecond (100 ps) radiation pulses at high repetition rates (up to 5 kHz). Molecules of Ni-octaethyl porphyrin in tetrahydrofuran solution were photoexcited by a high-power pulse pumping in YAG:Nd^{3plus}-laser and Raman scattering was induced by single pulses extracted from pulse trains of second-harmonic radiation from the YAG:Nd^{3plus}-laser through a $LiIO_3$ frequency-doubler crystal. Spectroscopy of spontaneous resonant raman scattering was done with conventional time resolution. Spectroscopy of resonant coherent anti-Stokes light scattering, with degenerate four-wave interaction, was done with picosecond temporal resolution. The authors thank S.A. Akhmanov, P.A. Apanasevich, and V.A. Orlovich for steady attentiveness and helpful discussions, A.M. Shulga for synthesizing and supplying NiOEP(THF) specimens. Figures 4; tables 2; references 17: 7 Russian, 10 Western.

2415/12232

Resonant Emission of Electromagnetic Waves by Plasma Solitons

18620133b Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 94 No 3, Mar 88 (manuscript received 22 Feb 87) pp 76-82

[Article by V.A. Mironov, A.M. Sergeyev and A.V. Khimich, Institute of Applied Physics, USSR Academy of Sciences]

[Abstract] The purpose of this work was an analysis of a new, important property of solitons in a magnetically active plasma—their ability to emit electromagnetic waves at the natural oscillating frequency of the electric field in the soliton. The effect is first studied in a homogeneous, weakly magnetized plasma, then its specifics are studied in a heterogeneous medium, as applicable to the interpretation of experimental results based on the observation of the natural radio-frequency radiation of the ionosphere arising when powerful radio waves interact with the F layer. The radiation of electromagnetic waves can be used as a diagnostic medium for investigation of plasma turbulence in the terrestrial magnetosphere. References 11: 7 Russian, 4 Western.

6508

Transparency of Asymmetrical Tunnel Microjunction and Quasiclassical Theory of the Scanning Tunnel Microscope

18620133a Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 94 No 3, Mar 88 (manuscript received 30 Jul 87) pp 7-22

[Article by M.Yu. Sumetskiy, Leningrad Electrical Engineering Institute of Communications imeni M.A. Bonch-Bruyevich]

[Abstract] The scanning tunnel microscope has renewed interest in the study of the permeability of three-dimensional asymmetrical microjunctions. The microscope achieves good resolution when the width of the tube within which the current is located is less than the characteristic radius of curvature of the surface studied. The theory of permeability of multidimensional asymmetrical potential barriers allows a significant advance in the production of analytic expressions for the transparency of asymmetrical tunnel microjunctions. This article develops the classical theory of permeability of these junctions in the one-electron approximation, deriving a general expression for the permeability of an asymmetrical potential barrier modeling a microjunction. The influence of localized states of electrons before the barrier on permeability of a microjunction and the scanning tunnel microscope image is studied. An expression for permeability is derived for a specimen with a point defect near its surface, when interference phenomena are possible. The quasiclassical approximation cannot correctly consider rapid changes in potential relief, a limitation of the scanning tunnel microscope as well. Effects related to several most probable tunneling paths are not analyzed in this article. Figures 4, references 29: 10 Russian, 19 Western.

6508

Envelope Solitons and Modulational Instability of Dipole-Exchange Spin Waves in Yttrium-Iron Garnet Films

18620122 Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 94 No 2, Feb 88 (manuscript received 3 Apr 87) pp 159-176

[Article by B.A. Kalinikos, N.G. Kovshikov, and A.N. Slavin, Leningrad Electrical Engineering Institute imeni V.I. Ulyanov (Lenin)]

[Abstract] Recently discovered concepts related to the theory of nonlinear waves in the physics of magnetic phenomena such as the concept of the soliton have stimulated new experiments dealing with nonlinear wave processes in magnetic crystals. This study examines nonlinear dipole-exchange spin waves in monocrystalline yttrium-iron garnet films. Because these films have record low values of the magnetic dissipation parameter at room temperature, they are especially well suited to the directed propagation of microwave magnetization waves for distances from units to tens of millimeters (100- to 1,000-fold greater than the length of a traveling wave). The experiments were conducted on a model delay line that consisted of two polycore plates with inlet and outlet spin wave antennas with microband feed lines. The plates were attached to a metal base that consisted of two movable halves, which made it possible to change the distance bwteeen the inlet and outlet antennas in a continuous manner from 3 to 10 mm. A clamp was used to fix the film specimens on the antennas. The model delay line was located in the gap of a constant magnet, thereby providing a magnetic field with the necessary magnitude and direction. Measurements were made at room temperature and in pulsed and continuous modes. Envelope solitons were only formed in narrow frequency regions of strong dispersion near the dipole slots in the spin wave spectrum of a film with pinned surface spins. The envelope solitons' speeds were shown to be independent of their amplitude. The measured values of the speed of individual solitons in a multisoliton propagation mode (with a precision up to the measurement error of the experiment, i.e., about 10 percent) were equal to one another. Under conditions of continuous monochromatic excitation, waves with the very same carrier frequency were found to exhibit modulational instability. At low supercriticalities, a nonlinear Schroedinger equation can serve as a basis for a theoretical explanation of the wave phenomena observed. At relatively high supercriticalities, however, the propagation pattern of nonlinear waves becomes substantially more complex, demanding further investigation. Figures 9; references 29: 28 Russian, 1 Western.

12794

UDC 533.9.01

Evaporation Rate of Macroparticles and Magnetohydrodynamic Plasma Perturbations During Injection of Macroparticles Into T-10 Tokamak

18620107 Moscow FIZIKA PLAZMY in Russian Vol 14 No 1, Jan 88 (manuscript received 25 Sep 86, after correction 17 Mar 87) pp 3-9

[Article by B. V. Kuteyev, V. Yu. Sergeyev, and A. P. Umaov, Leningrad Polytechnic Institute imeni M. I. Kalinin]

[Abstract] An experimental study of a tokamak plasma with injection of deuterium or graphite macroparticles was made, fluctuations of their evaporation rate and MHD perturbations in the plasma known to occur during injection. 1.35 mm large deuterium particles at a velocity of 600-700 m/s and 0.003-0.004 mm large graphite particles with a velocity of 100-140 m/s were injected separately toward the center of the discharge chamber of the T-10 tokamak. Using a stable collimated reference photodiode along with a viewing one ensured "locking" the curves of evaporation rate kinetics in space within 1.5 cm and facilitated monitoring the breakup of macroparticles during measurement of the evaporation rate and recording, with 24 probes, poloidal MHD perturbation modes of orders 1-6. The data are now analyzed considering seven factors possibly responsible for variation of the evaporation rate: 1. breakup of macroparticles during their acceleration or evaporation, 2. rotation of macroparticles with attendant variation of their surface area exposed to the vaporizing thermal flux, 3. excursion of macroparticles beyond the field of vision, 4. variance of the injection phase with respect to internal collapse, 5. variance of the injection phase with respect to structure of magnetic isles, 6. fast MHD restructurization of the plasma within a time comparable with the macroparticle evaporation time, 7. cooling of magnetic surfaces with ratios m/n (m- order number of poloidal mode, n- order number of toroidal mode). The results indicate that the evaporation rate of deuterium fluctuates strongly in the region where ration m/n is equal to 1, its fluctuations in the region where ration m/n is larger than 1 tentatively not being attributable to movement of certain magnetic surface, while the evaporation rate of graphite fluctuates strongly in the region where ration m/n is larger than 1 and especially where it is 3/2 or 2. Injection of deuterium is found to cause MHD perturbations with in differently behaving modes. Injection of graphite is found to cause weak MHD perturbations, sufficient for identifying the magnitude of the m/n ratio only. The authors thank V. V. Volkov, N. V. Ivanov, and P. P. Khvostenko for information about MHD modes, and the T-10 staff for facilitating the performance of experiments. Figures 4; references 11: 5 Russian, 2 Hungarian, 4 Western (1 in Russian translation).

UDC 550.385

Heating of Ions and Anomalous Resistance During Ion-Cyclotron Instability of Plasma

18620107 Moscow FIZIKA PLAZMY in Russian Vol 14 No 1, Jan 88 (manuscript received 25 Jun 86, after correction 14 Jan 87) pp 39-45

[Article by A. S. Volotkin and V. G. Mordovskaya, Institute of Terrestrial Magnetism, Ionosphere, and Radiowave Propagation]

[Abstract] Steady-state EIC-turbulence in auroral plasma is analyzed on the basis of the quasi-linear theory for ions, this turbulence being characterized by an anomalous resistance and attendant heating of ions. The turbulence spectrum is calculated, assuming a turbulence confined within a segment of finite length along the external magnetic field within which both the anomalous resistance and the mean intensity of the external magnetic field are significant. Included is the electronic part of the cyclotron-instability increment, but nonlinear interaction of EIC-waves is ignored. From the equation of ion heating by EIC-waves in a collisionless plasma and the equation for wave attenuation due to resonant wave-ion interaction, considering only the fundamental-mode resonance, first the spectrum of EIC-waves and then the velocity distribution of accelerated ions $f_i(v_v,v_z)$ (v_t- transverse velocity, v_z- longitudinal velocity) are determined. The wave spectrum is found to be jet-like, as usually in the case of weak turbulence with any continuously differentiable ion velocity distribution function. The anomalous resistance is calculated, assuming that ions absorb the entire momentum transferred to them from electrons under an image force. The contradiction between weak turbulence according to the quasi-linear theory and strong turbulence according the dependence of the anomalous resistance on the turbulence level can be removed by considering an energy dissipation faster than under an image force, say, drain of ions accelerated by nonresonant heating. The authors thank A. A. Galeyev and V. N. Orayevskiy for helpful discussions and comments. Figures 1; references 17: 3 Russian, 14 Western.

UDC 533.95

Diagnostic Examination of Neutral Plasma Component During Compression of Microspheres by Laser Pulse

18620107 Moscow FIZIKA PLAZMY in Russian Vol 14 No 1, Jan 88 (manuscript received 10 Mar 87) pp 77-83

[Article by N. G. Basov, Yu. A. Zakharenkov, A. A. Karnaukhov, G. V. Sklizkov, and A. S. Shikanov, Institute of Physics imeni P. N. Lebedev, USSR Academy of Sciences, J. Wolowski, S. Denus, W. Mroz, and J. Farny, Institute of Plasma Physics and Laser Microfusion imienia S. Kalinski, Warsaw/Poland]

[Abstract] An experiment with spherical microshells containing deuterium-tritium gas and their compression by means of a laser pulse for thermonuclear fusion of

that gas was performed, the object being to measure their mass by time-of-flight spectroscopy of the neutral-particle flux in the plasma of microshell material generated in the process and to thus determine the hydrodynamic coefficient of energy transfer from laser beam to target material more accurately than by other known methods such as x-ray spectroscopy of compressed gas or kinetics of reaction products based on corpuscular diagnosis of compressed nuclei. A time-of-flight analyzer of neutral as well as charged particles has been designed and built for this purpose. A thin plasma beam 4 mm in diameter is formed by a diaphragm for passage through the analyzer chamber in a transverse electrostatic field which deflects ions and electrons in opposite directions while letting neutral atoms pass through the chamber undeflected. The chamber is formed by a 60 mm long copper cylinder 8 mm in diameter with a 3 mm wide longitudinal slot. The electrostatic field is produced by application of a direct voltage to two electrodes with teflon insulation, this voltage being variable over the o-3 kV range of either polarity. Three 5-Mohm resistors limit the bias current, three 50-ohm resistors match the chamber of coaxial feeder cables, and two capacitors, 1 microfarad and 0.1 microfarad respectively, decouple the measuring circuit from the bias circuit. Permanent magnets at both ends of the chamber produce a longitudinal magnetic field which suppresses secondary electron emission. Neutral atoms are collected by a semiconductor-type detector (BRUR-30 Si diode with thin dead p-Si layer) or by a microchannel plate. This analyzer was tested experimentally in the Delfin facility with laser pulses of 1.5-2 kJ energy and 2 ns duration, on 0.002-0.006 mm thick glass microshells 0.400-0.800 mm in diameter. Both sensitivity and accuracy of such an analyzer can be improved by reducing the thickness of the dead layer in the detector diode and lowering the threshold velocity so that slower neutral atoms can be recorded. Figures 5; references 33: 19 Russian, 2 Polish, 12 Western.

2415/9274

Nature of Anomalous Electron Transport Across Magnetic Field in Trap With Steep Density Fall

18620128 Moscow FIZIKA PLAZMY in Russian Vol 14 No 2, Feb 88 (manuscript received 21 Jan 87, after correction 21 May 87) pp 170-180

[Article by V.V. Piterskiy, V.P. Pastukhov, M.S. Ioffe, B.I. Kanayev, and Ye.Ye. Yushmanov, Institute of Atomic Energy imeni I.V. Kurchatov]

[Abstract] An experimental study of the Atoll magneto-electrostatic plasma trap was made, this trap being formed by a quadricuspidal magnetic field with electrostatic barriers blocking the gaps between segments of the surrounding ring structure. The purpose was to monitor and explain the anomalous electron transport across the magnetic field in this trap as a result of the steep radial fall of plasma density characterizing such a trap configuration. The plasma was searched with a pair of probes variously spaced for recording the high-frequency spectrum of plasma potential fluctuations, each probe passing through a capacitively-grounded cylindrical floating shield and capacitively insulated from a low-pass filter. A theoretical analysis of the results has revealed three instability modes in such a trap, only two of them being responsible for anomalous transverse electron transport. They are the long-wave ion-acoustic instability and the lower-hybrid drift instability, the diocotron instability not playing a role here. Figures 5; references 14: 8 Russian, 4 Western.

/09599

Erosion Resistance of TiN Coatings and Possibilities of Their Use for Protection of Electrically Stressed Equipment in Thermonuclear Plants

18620050 Moscow FIZIKA PLAZMY in Russian Vol 13 No 10, Oct 87 (manuscript received 16 Jul 86, after correction 8 Dec 86) pp 1256-1261

[Article by Ye.D. Volkov, Ya.F. Volkov, I.I. Demidenko, V.G. Dyatlov, B.P. Ilenko, V.Ya. Kolot, V.G. Konovalov, N.S. Lomino, N.I. Nazarov, O.S. Pavlichenko, G.N. Polyakova, L.N. Remez, K.S. Rubtsov, S.I. Solodovchenko, A.N. Shapoval, and O.M. Shvets, Kharkov Institute of Engineering Physics]

[Abstract] An experimental study of TiN coatings on Cr12Ni10Ti stainless steel bombarded by monoenergetic ion beams or by plasma streams was made, for the purpose of determining their erosion resistance and changes in their composition under such conditions. Their composition was determined on the basis of backscattering of 1.3 MeV H^+-ions, the carbon content being determined on the basis of secondary emission of C^+ and O^+ ions. The erosion rate was measured by the weighing method under bombardment by 2 keV He^+ or Ar^+ ions, for reference also under bombardment by 80 keV ions, with the temperature of specimens allowed to rise from 20°C to 190°C. Microphotographs before and after bombardment revealed flaking of bare steel and initiated but then suppressed blistering of 3 gmm thick coatings. The rate of electrical erosion by arcing was measured in a facility with slow 0-pinch in an azimuthal magnetic field, discharge of 25 gms duration producing a plasma with an electron concentration n_e [equivalent to] $5 \cdot 10^{13}$ cm^{-3} and an electron temperature T_e [equivalent to] 50 eV. Data on unipolarity arc tracks adequate for statistical analysis were obtained with 25 such discharges. Subsequent tests were performed with TiN coatings on the small 200 kW high-frequency antenna of the "Uragan-3" torsatron, the electrically most highly stressed component of a thermonuclear fusion plant, which generated and heated the plasma in pulses of 3 ms duration under a vacuum of 10^{-5} torr at frequencies within the range of ion-cyclotron and Alfven resonances. The results indicate a high effectiveness of TiN coatings on stainless steel, these coatings

being almost impermeable to hydrogen and their resistance to erosion, especially electrical erosion, being much higher than that of stainless steel. Figures 5; references 12: 8 Russian, 4 Western.

2415/9604

Concerning Small-Scale Turbulence of Magnetic Field and Density of Plasma in FT-2 Tokamak

18620201 Leningrad PISMA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian
Vol 13, 12 Feb 87 (manuscript received 3 Nov 86) pp 179-183

[Abstract] The article is concerned with determination of the interrelation between fluctuations of the electron concentration and the magnetic field in the peripheral zone of a Tokamak. The results obtained, using the method of Co_2 laser emission scattering, and of a RF magnetic probe, are presented. These procedures are described. The authors thank V.A. Rozhanskiy for a fruitful discussion of the results obtained. Figures 2; references 5: 3 Russian.

6415/9604

Kinetics of Initial Stage in Development of Beam-Induced Plasma Discharge

18620164 Moscow FIZIKA PLAZMY in Russian
Vol 13 No 3, Mar 87 (manuscript received 27 Jan 86, after revision 11 Jun 86) pp 366-370

[Article by G.I. Guseva, K.K. Dmitiyev, M.A. Zavyalov, V.A. Leytan, and A.S. Roshal, All-Union Institute of Electrical Engineering imeni V.I. Lenin, Moscow Institute of Engineering Physics]

[Abstract] The initial stage in development of a beam-induced plasma discharge is described in accordance with the hybrid gas-kinetic theory. A nonrelativistic one-velocity electron beam at zero temperature is assumed to enter an optically thin volume of a one-component gas with uniform density, heavy particles such as molecules and ions remaining stationary during the initial period of time while the electron beam crossing the entire volume becomes neutralized by ions. The corresponding system of equations of transport for such an electron beam is solved by the method of separation of physical processes and splitting into time intervals. The longitudinal profile of electric field intensity is calculated according to Gauss's theorem as a function of dimensionless time, time normalized to the initial electron transit time. Calculated are also the energy of beam electrons in longitudinal motion and in transverse motion, their maximum and minimum total energy, the beam density and the plasma density as well as the mean plasma electron temperature within the interaction space during the transient period. These calculations are based on the "large particles" model of an electron beam. Computer calculations for an initially 7 keV electron beam propagating initially at a velocity $v_0 = 4.96 \cdot 10^7$ m/s through an $l = 1.5$ m long tube with molecular nitrogen under a pressure of $8 \cdot 10^{-4}$ torr at a temperature $T = 293$ K, the initial transit time being $[Tau]_0 = 1/u_0 = 3.02 \cdot 10^{-8}$ s, reveal that the initial stage of discharge development consists of three distinct segments: impact ionization of the gas with resulting linear plasma buildup—acceleration of plasma electrons in self-consistent electric field of high-frequency plasma oscillations involving principally plasma electrons—avalanche plasma buildup resulting in steep rise of the electric field amplitude and the plasma electron temperature as well as in retardation and even reversal of beam electrons. The motion of beam electrons becomes randomized very soon, already after a time $t = 20[Tau]_0$. The authors thank A.A. Rukhadze chairing the scientific seminar held at the Institute of General Physics, USSR Academy of Sciences, and participants of that seminar for fruitful discussion. Figures 3; references 7: 2 Russian, 5 Western (all in Russian translation).

2415/9604

Spectral and Energy Characteristics of Electromagnetic Radiation Emitted by Laser Plasma

18620164 Moscow FIZIKA PLAZMY in Russian
Vol 13 No 3, Mar 87 (manuscript received 12 Mar 86, after revision 4 Jun 86) pp 342-349

[Article by G.A. Vergunova, A.A. Kologrivov, V.B. Rozanov, G.V. Sklizkov, and A.S. Shikanov, Institute of Physics imeni P.N. Lebedev, USSR Academy of Sciences]

[Abstract] For a study of radiation emitted by a laser plasma of a light metal, fundamental-wavelength radiation of a Nd-laser was focused on a bulk aluminum target with a power density of the order of 10^9 W/cm^2 in pulses of 20-50 J energy and 1.5 ns duration forming a focal spot 200 gmm in diameter. The radiation spectrum of the aluminum plasma was measured and comprehensively diagnosed, its 0.5-7 [Angstrom] region by the method of reconstruction from attenuation curves with detectors and filters and its 20-200 [Angstrom] region by the method of spectrography. As detectors for the short-wave region were used UF-VR photographic film, scintillators, and photomultipliers with a set of filters ranging from 100 gmm thick beryllium to 5 mm thick aluminum. The spectrograph for the longwave region employed a diffraction grating and sliding incidence, in preference to one with high-molecular crystals, namely a Hilger & Watts E-580 spectrograph and a gold diffraction grating oriented at an 86° angle to incident radiation with 576 lines/mm, a 2 m radius of curvature, and 1.6° glance angle. The experiment was performed in the Kalmar facility at the Institute of Physics. The spectrum was recorded on Ilford Q-2 photographic plate. The results based on a theoretical analysis of experimental data, including estimation of errors of both methods, are compared with computer calculations according to the "Rim" program. The agreement is close within the 2-5.5

[Angstrom] region of the spectrum. Measurements have yielded higher energy in the shorter-wave region owing to presence of fast electrons in the plasma and lower energy in the longer-wave region beyond 40 [Angstrom] owing to low sensitivity, most of the energy of radiation emitted by aluminum plasma being concentrated within the 7-20 [Angstrom] region of the spectrum. The total energy is, moreover, found to be altogether much lower than the incident laser radiation energy. Figures 5; tables 3; references 19: 16 Russian, 3 Western.

2415/9604

Interaction of Strong Electromagnetic Wave and Layer of Dense Magnetized Plasma

18620164 Moscow FIZIKA PLAZMY in Russian
Vol 13, No 3, Mar 87 (manuscript received 28 May 86) pp 300-306

[Article by A.K. Kotov, A.V. Kochetov, and A.M. Feygin, Institute of Applied Physics, USSR Academy of Sciences]

[Abstract] Interaction of a homogeneous layer of dense magnetized plasma and a strong polarized electromagnetic wave passing through it is analyzed, their interaction resulting in peculiar physical anomalies, causing the plasma to become anisotropic. A plane electromagnetic wave is assumed to be normally incident from vacuum on a homogeneous plasma layer in a uniform magnetic field, the resulting plasma concentration profile in this layer being determined by the average ponderomotive force and the nonlinearity of striction. The plasma is assumed to be cold and collisionless, containing electrons only. Self-consistent electron concentration and electromagnetic field distributions in the layer as well as the dependence of the reflection coefficient at the vacuum-plasma boundary on the amplitude of the incident wave are calculated by representing the resultant field as a superposition of the incident wave and the reflected one, then solving the field equations for the tangential components E_y,H_z and the longitudinal component E_x. Upon normalization of the parameters to dimensionless ones, solution of the problem in the phase plane first for a boundless plasma and then for a finite plasma layer yields nonlinear field and plasma structures with alternate regions of positive and negative dielectric permittivity. The modulus of the reflection coefficient fluctuates from 1 to zero and from successively smaller maxima to zero as the amplitude of the incident wave decreases and depending on the field pattern in the layer. Several equilibrium states are found to exist in the phase plane, the central one lying where the plasma is densest and attainable with an amplitude of the incident wave within a finite range between two critical ones. Figures 3; references 15: 13 Russian, 2 Western.

2415/9604

Disintegration of Graphite Walls in TM-G Tokamak

18620164 Moscow FIZIKA PLAZMY in Russian
Vol 13 No 3, Mar 87 (manuscript received 19 Sep 85, after revision 12 May 86) pp 269-281

[Article by M.M. Dremin, Yu.D. Pavlov, D.P. Petrov, A.M. Solntsev, A.M. Stefanovskiy, and A.L. Terebkov, Institute of Atomic Energy imeni I.V. Kurchatov]

[Abstract] For the purpose of completing the model of discharge in a tokamak, disintegration of the graphite walls around the discharge chamber and of the round graphite diaphragm in a TM-G tokamak with a 0.4 m radius and a 0.078 m gap width operating at a magnetic induction of almost 4 T is evaluated on the basis of experimental data and theoretical analysis. A circular array of 24 coils energized by discharges of a capacitor bank produced a toroidal magnetic field in pulses of approximately 60 ms duration, while plasma current pulses of approximately 15 ms duration were produced by the primary winding of an iron-core transformer and shaped to near-square-waveform by an artificial transmission line. The initial gas pressure in the discharge chamber was attained by passage of hydrogen either in a continuous stream or in a spurt synchronized with a magnetic field pulse. Tests were run with the walls at a temperature of 350°C and at room temperature. Pressure readings and oscillograms covering transients and the residual steady state over a period of several discharges served as indicators of processes occurring in the tokamak. Theoretical analysis of these processes involves quantitative analysis of chemical and physical hydrogen-graphite interactions. Chemical interaction results in production of hydrocarbons, principally methane and ethane. Physical interactions include diffusion of hydrogen into the graphite walls and reflection of hydrogen ions by the walls with attendant desorption of hydrogen. Calculations based on a phenomenological model including relevant theoretical atomic and molecular concentrations yield a lower than true value of the graphite disintegration coefficient. Measurements have yielded a higher than true value of this coefficient. Calculations and measurements can be reconciled by appropriate correction factors. The authors thank V.I. Kostikov, V.Ya. Tsarev, G.A. Tupova, P.F. Lavruzhin, and T.P. Maruyev for organizing the assembly of graphite structures to be installed in the TM-G tokamak, also their colleagues participating in the experiment for collaboration and discussion of the results. Figures 8; references 15: 6 Russian, 9 Western.

2415/9604

Heating of Plasma in L-2 Stellarator at Fundamental Ion-Cyclotron Frequency

18620164 Moscow FIZIKA PLAZMY in Russian
Vol 13 No 3, Mar 87 (manuscript received 4 Feb 86) pp 259-267

[Article by V.A. Batyuk, G.S. Voronov, Ye.F. Gippius, S.Ye. Grebenshchikov, N.P. Donskaya, K.S. Dyabilin, B.I. Ilyukhin, I.A. Kovan, L.M. Kovrizhnykh, A.I. Meshcheryakov, P.Ye. Moroz, I.S. Sbitnikova, V.N. Sukhodolskiy, and I.S. Shpigel, Institute of General Physics, USSR Academy of Sciences]

[Abstract] Heating of a hydrogen plasma at the fundamental ion-cyclotron frequency was studied experimentally in an L-2 stellarator, a double-thread toroidal magnetic trap with a 100 cm larger radius and a 17.5 cm smaller radius of the vacuum chamber. At an gy = 0.228 relative amplitude of the fundamental field component, the plasma was confined by a magnetic separatrix with a mean radius of 11.5 cm. The intensity of the longitudinal magnetic field was varied over the 10-14 kG range. With gas admitted into the chamber in spurts, plasma was produced by Joule-effect heating with a current of 16-20 kA. A mean electron concentration as high as $2 \cdot 10^{13}$ cm^{-3} was reached, with the electron temperature at the center of the plasma filament initially 450 eV and dropping to 300 eV at the maximum electron concentration. The initial ion temperature was 80-90 eV. An RF oscillator employing GI-27 tubes is used as the source of ion-cyclotron heating of the plasma with self-excitation and with pulse duration control up to 20 ns. Fast magnetoacoustic waves were excited in the plasma by an antenna with 1/4-wavelength of 3/4-wavelength coaxial feeder cables tuned to the oscillator resonance frequency. A maximum power of 100-150 kW or more than double the Joule-effect heating power was thus pumped into the plasma at the maximum high-frequency voltage of 30 kV, with the initial ion temperature rising to approximately 300 eV. The oscillator frequency was varied over the 18-19 MHz range, with two different kinds of antenna connected. Most tests were run with a partially shielded antenna, at a frequency of 18 MHz and corresponding resonance magnetic field intensity of 12 kG, some tests were run with a completely electrostatically shielded set of two antennas. The results of plasma probing and diagnostic measurements, including evolution and decay of ion waves, reveal a very efficient absorption of high-frequency power in this stellarator with attendant ion-cyclotron heating of ions at the center of the plasma. They also indicate that interaction of plasma and stellarator wall during ion-cyclotron heating is not resonantly dependent on the magnetic field intensity and not related to heating of the bulk plasma. Figures 2; references 13: 5 Russian, 8 Western.

2415/9604

Nonlinear High-Frequency Plasma Oscillations in Crossed Fields

18620122 Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 94 No 2, Feb 88 (manuscript received 17 Jul 87) pp 93-101

[Article by Yu. B. Movsesyants, All-Union Electrical Engineering Institute imeni V.I. Lenin]

[Abstract] The stability of the strongly nonlinear high-frequency oscillations of an axiosymmetric, charged cold plasma column directed along an applied magnetic field is one of the pressing problems in forming and transporting high-power electron beams and using them to generate waves of magnetic plasma. The longitudinal dimension of such a column is generally much greater than its lateral dimension. For nonsteady processes with times approximately equal to ω_{pe}^{-1} (ω_{pe} being the electron plasma frequency), the ions are assumed to be stationary, and the electron's flow rate is much higher than thermal. When this is the case, the problem is reduced to a study of the nonlinear dynamics of cold electron plasma in crossed radial electrical fields as well as longitudinal and azimuthal magnetic fields. Such dynamics have been relatively well studied only when ω_{pe} is much less than ω_{Be} (ω_{Be} being the electron cyclotron frequency). In many applications, however, the mode wherein ω_{pe} is approximately equal to ω_{Be} is of interest. When such is the case, an allowance must be made for the the plasma's diamagnetism, and the total magnetic field may not be consisdered homogeneous. The resultant magnetic pressure gradient may lead to a rapid build-up of oscillations, with the ultimate formation of discontinuities in the charge density and flow rate distributions. The reverse process—an increase in the drift current that increases the pressure gradient and results in a stabilization of the flow—may also occur under specified conditions. These processes can only be correctly described in a self-matched system. This article uses nonrelativistic hydrodynamic equations for cold plasma as a basis for describing the aforementioned processes. A class of exact solutions describing charge and current profiles that are stable relative to the nonlinear weakly nonpotential oscillations of the electron component of plasma are derived. Unlike the purely potential harmonic oscillations in the applied longitudinal magnetic field, in which case the form of the spatial distributions of the functions does not affect the system's time characteristics, here the specified charge density and current profiles correspond completely to stable nonlinear oscillations. In the event of a weak diamagnetism of the flow, making an allowance for the drift current leads only to an anharmonicity of the oscillations. Given specified ratios between the parameters, the presence of an ion background coupled with a strong diamagnetism of the flow leads to the appearance of a new branch of oscillations possessing a threshold saturation effect. The form of this branch is close to the unstable equilibrium point, and the evolutionary characteristic of the charge density profile confirms the possibility of the existence of weakly nonlinear spiral waves of the envelope soliton type. References: 6 Russian.

12794

Superconducting Weak Link of Ceramic Material With Transition at Near 90 K in Microwave Field

18620135a Moscow PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 47 No 7, 10 Apr 88 (manuscript received 27 Jan 88) pp 335-337

[Article by N.V. Zavaritskiy, Institute of Problems in Physics, and V.N. Zavaritskiy, Institute of General Physics, USSR Academy of Sciences]

[Abstract] For a study of superconducting weak links with a superconducting transition temperature above 77 K, the boiling point of nitrogen, bridges with dimensions of the order of 0.01 cm were removed from high-stability interferometers for measurement of their current-voltage and dV/dI-V characteristics. The material of these bridges was $YBa_2Cu_3O_7$ ceramic, their critical current increasing from (5-50)• 10^{-5} A at 77 K to (3-300)• 10^{-3} A at 4.2 K and found to be a periodic function of the intensity of the external magnetic field. In microwave fields of 25-40 GHz frequency on their current-voltage characteristic current jumps appeared at multiples of the voltage, proportional to the frequency. The necessary condition for attainment of a weak link appears in fabricating this ceramic by solid-phase chemical synthesis reaction so that a structure with a thinned lattice containing "filaments" with cross-sections smaller than those of a ceramic grain will result. The authors thank N.A. Nikitin for assistance in experiments, A.I. Larkin for helpful discussions, and A.I. Smirnov for supplying microwave hardware. Figures 3; references 10: 3 Russian, 7 Western (1 in Russian translation).

Optical Properties of $YBa_2Cu_3O_{7-y}$ Single Crystals and Characteristics of Their Conductivity Mechanism

18620135b Moscow PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 47 No 7, 10 Apr 88 (manuscript received 10 Feb 88) pp 338-340

[Article by A.A. Samokhvalov, N.M. Chebotayev, N.N. Loshkareva, Yu.P. Sukhorukov, V.A. Kostylev, B.A. Gizhevskiy, and S.V. Naumov, Institute of Metal Physics, Ural Department, USSR Academy of Sciences]

[Abstract] An experimental study of $YBa_2Cu_3O_{7-y}$ single crystals was made for a determination of their optical properties, namely their reflection and absorption spectra at room temperature. Specimens, 0.020-0.200 mm thick and up to 4x4 mm^2 large wafers, were grown from solution in the melt and then heat treated. Those quenched from 900 deg C had a tetragonal structure and those quenched from below 800 deg C had a rhombic structure. Both reflection and absorption spectra were measured over the 700-14,000 nm range of wavelengths in an IKS-21 spectrometer at room temperature. Measured were also electrical resistivity and the Hall effect. The reflection coefficient of all rhombic crystals was found to increase as the incident radiation shifted toward longer waves, especially steeply with a shift from 800 nm to 900 nm. Their absorption spectra were found to contain a peak with the maximum at a wavelength depending on the oxygen content, namely shifting toward longer wavelength and its magnitude increasing with higher oxygen content (smaller deficiency parameter y). This peak therefore does not represent an intracentral transition and is not associated with oxygen deficiency but rather with local excitations of charge carriers. Prolonged tempering in an oxygen atmosphere made these single crystals opaque. Both absorption coefficient and refractive index were found to increase with long-wave shifting of the incident radiation, the refractive index from 4.5 to 8.0 and the real part of the complex dielectric constant correspondingly from 20 to 60 as the wavelength of the incident radiation shifted from 2000 nm to 6000 nm. The optical conductivity of these single crystals throughout the entire range of wavelengths under consideration consists evidently of at least two components, a Drude component contributed by free charge carriers and a component contributed by bound charge carriers upon their absorption of radiation. The electrical resistivity of these single crystals at room temperature was 10^{-3}-10^{-1} ohm• cm in the plane of the wafer and 20-30 times lower in the normal direction, the Hall mobility was slightly lower than 0.1 $cm^2/(V• s)$. Figures 2; references 10: 5 Russian, 5 Western.

Analysis of Some Experimental Data on High-Temperature Superconductor Materials

18620135c Moscow PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 47 No 7, 10 Apr 88 (manuscript received 23 Feb 88) pp 351-353

[Article by L.P. Gorkov and N.B. Kopnin, Institute of Theoretical Physics imeni L.D. Landau, USSR Academy of Sciences]

[Abstract] Experimental data on the two new high-temperature superconductor materials $YBa_2Cu_3O_7$ and $La_{1.85}Sr_{0.15}CuO_4$ are analyzed theoretically for significance of fluctuations during superconducting transition and for their fitting the Fermi-fluid model. Most typical values of the relevant parameters are considered, the spread of their readings being very wide. The upper critical magnetic field, the coherence parameters, the penetration depth, and the specific heat within the temperature range of superconducting transition for $YBa_2Cu_3O_7$ ("pure" limit) and $La_{1.85}Sr_{0.15}CuO_4$ ("dirty" limit) are described analytically and evaluated numerically with the aid of both Ginzburg-Landau and Bardeen-Cooper-Schrieffer theories, these properties of "pure" La_2CuO_4 then being estimated only because of poor reproducibility of available experimental data. The authors thank V.P. Mineyev and G.M. Eliashberg for helpful comments. Tables 1; references 19: 5 Russian, 14 Western.

Anomalies in Temperature Dependence of Mossbauer-Spectrum Parameters of $YBa_2Cu_{2.95}Fe_{0.05}O_{7-y}$ Superconductor Ceramics

18620135d Moscow PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 47 No 7, 10 Apr 88 (manuscript received 23 Feb 88) pp 354-356

[Article by V.M. Cherepanov, M.A. Chuyev, S.S. Yakimov, V.Ya. Goncharov, and S.A. Smirnov, Institute of Atomic Energy imeni I.V. Kurchatov]

[Abstract] Mossbauer spectra with two doublets of ^{57}Fe in $YBa_2Cu_{2.95}Fe_{0.05}O_{7-y}$ ceramics (y ranging from 0.1 to 0.3) where it replaces some Cu were measured at temperatures from below to above the 15 K wide superconducting transition range about the 75 K center point, x-ray diffraction analysis of these ceramics having established an orthorhombic single phase in their structure. Five parameters characterizing the partial spectrum of each doublet and also the Debye temperature have been evaluated on the basis of these measurements, with the temperature range subdivided into three (4.2-75 K, 75-200 K, 200-293 K) and the values of these parameters averaged over each. The five parameters include isometric shift, quadrupole split, sigma polarizability, ratio of pi-component to sigma-component intensities, and asymmetry factor in the Goldanskiy-Karyagin effect. All five were found to become anomalous near the superconducting transition, the Debye temperature to increase from 430 K (average) within the 4.2-75 K range to 470 K (average) within the 200-293 K range. Calculation of the electric-field gradient in both Fe positions could, in the first approximation, be reduced to calculation of its lattice component contributed by ions in the nearest surrounding. The authors thank Yu. Kagan discussing the results, I.K. Kobrin and A.V. Inyushkin for x-ray diffraction and electrophysical analysis of specimens. Figures 3; tables 1; references 9: 5 Russian, 4 Western.

Equation of State for Single Crystals of $YBa_2Cu_3O_x$ High-Temperature Superconductor and Their Compressibility Over Pressure Range Up to 20 GPa

18620135e Moscow PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 47 No 7, 10 Apr 88 (manuscript received 24 Feb 88) pp 357-360

[Article by I.V. Aleksandrov, A.F. Goncharov, and S.M. Stishov, Institute of Crystallography imeni A. V. Shubnikov, USSR Academy of Sciences]

[Abstract] In an experimental study of the $YBa_2Cu_3O_x$ high-temperature superconductor single crystals of both its tetragonal and rhombic phases were tested for the pressure dependence of their lattice parameters in the high-pressure range up to 20 GPa. This dependence has been established on the basis of four test series and subsequent calculations yielding the linear compressibility, the "two-dimensional" compressibility, and the bulk modulus. The results reveal that the linear compressibility in the (a,b) plane depends on and the "two-dimensional" compressibility almost does not depend on presence or absence of oxygen in the (x,y,0) plane, while the compressibility along the c-axis and thus also the volume compressibility or the bulk modulus depends strongly on the oxygen content in that plane. This establishes definitely that the effect of "excess" oxygen on the crystal structure and on the mechanical properties of $YBa_2Cu_3O_x$ single crystals is inherently related to changes in the electronic subsystem in these crystals and thus to appearance of anisotropic long-range forces which contract the crystal lattice along the c-axis ensuring a rhombic deformation. The authors thank O.K. Melnikov, A.B. Bykov, I.P. Zibrov, and A.Ya. Shapiro for preparing specimens. Figures 3; tables 1; references 7: 2 Russian, 5 Western.

Instability of $YBa_2Cu_3O_{7-y}$ Crystal Lattice Within 240-200 K Temperature Range According to Data on Raman Scattering of Light

18620135f Moscow PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 47 No 7, 10 Apr 88 (manuscript received 8 Feb 88 and Mar 88) pp 360-363

[Article by L.A. Rebane, T.A. Fimberg, Ye.M. Fefer, G.E. Blumberg, and E.R. Joon, Institute of Chemical and Biological Physics, ESSR Academy of Sciences]

[Abstract] An analysis of spectra of Raman light scattering by the $YBa_2Cu_3O_{7-x}$ crystal lattice has revealed a new kind of its instability, within the 240-200 K temperature range, involving formation of complexes with a vibration frequency of 640 cm^{-1}. Specimens of this material were produced by the standard method from a mixture of Y_2O_3, $BaCO_3$, CuO powders, compacted at a temperature of 900-950 deg C in oxygen stream for 10 h. The compacts were thoroughly crushed and the powder was again compacted. The new compacts were treated with three heating-cooling cycles, after which their electrical resistivity at room temperature was 1-2 mohm• cm and their superconducting transition temperature reached the narrow 91-90 K range. Their oxygen deficiency x was slightly less than 0.1, according to the known dependence of that critical temperature on the oxygen content. The specimens were excited with an Ar^{plus}-laser, its beam being focused on a spot 0.060 mm in diameter and its power not exceeding 50 mW. The spectra of Raman

scattering were recorded with an "OMARS-89" spectrometer in the "back-scattering" configuration, at temperatures ranging from 300 K to 8 K. The temperature dependence of the spectral location and the intensity of four principal vibration bands characterizing the orthorhombic phase (500 cm^{-1}, 432 cm^{-1}, 340 cm^{-1}, 150 cm^{-1}) indicates that the 150 cm^{-1} band is the only one sensitive to high-temperature superconducting transition. Their anomalous frequency shifts and flareup within the 240-200 K temperature range indicate instability of the crystal lattice with attendant changing of the lattice constants and formation of metastable octahedral CuO_6 complexes, after intermediate formation of O(1)-Cu(1)-O(1) chains, which results in upward frequency shift of both 500 cm^{-1} and 340 cm^{-1} bands as well as appearance of a 640 cm^{-1} band. These conclusions agree with data already obtained by the nuclear-magnetic-resonance method. The authors thank K.K. Rebane for steady support and helpful discussions. Figures 3; references 10: all Western.

/09599

Raman Light Scattering in Single Crystals of $YBa_2Cu_3O_x$ High-Temperature Superconductor Compounds

18620121a Moscow PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 47 No 4, 25 Feb 88 (manuscript received 16 Dec 87) pp 184-187

[Article by I.V. Aleksandrov, A.B. Bykov, A.F. Goncharov, V.N. Denisov, B.N. Mavrin, O.K. Melnikov, and V.B. Podobedov, Institute of Spectroscopy and Institute of Crystallography, USSR Academy of Sciences]

[Abstract] An experimental study of tetragonal and rhombic $YBa_2Cu_3O_x$ single crystals was made, the first such study, for an analysis of their Raman light scattering spectra. Tetragonal crystals were grown from nonstoichiometric mixtures of Y_2O_3, $BaCO_3$, CuO powders at a temperature within the 900-1,000 deg C range in a platinum crucible. Their superconducting transition temperature varied over the 40-60 K range. Annealing them at 700 deg C in a He-atmosphere converted them into semiconductor crystals. Annealing them in an O_2-atmosphere converted them into orthorhombic crystals with a 93 K superconducting transition temperature. Raman scattering in crystals of both superconducting phases was excited with 514.5 nm light from an Ar^{plus}-laser and recorded over the 30-700 cm^{-1} range with 5 cm^{-1} resolution in a multichannel triple spectrometer. The spectra of both phases were found to be generally similar, except for absence of the wide 595 cm^{-1} band and presence of extra bands including the 232 cm^{-1} one in the spectra of rhombic crystals. Their spectra differ also with respect to energy shifts of several bands, most prominently of the most intense band near 500 cm^{-1} with an already known frequency shift depending on the oxygen content x. The authors thank S.M. Stishov and G.N. Zhizhin for interest and helpful discussions, I.N. Makarenko for advice regarding preparation of specimens, A.Ya. Shapiro and I.P. Zibrov for annealing the crystals. Figures 2; references 6: 1 Russian, 5 Western.

Electrical Resistivity and Specific Heat of Disordered $YBa_2Cu_3O_{7-y}$ Compound

18620121b Moscow PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 47 No 4, 25 Feb 88 (manuscript received 29 Dec 87) pp 193-196

[Article by S.A. Davydov, A.Ye. Karkin, A.V. Mirmelshteyn, I.F. Berger, V.I. Voronin, V.D. Parkhomenko, V.L. Kozhevnikov, S.M. Cheshnitskiy, and B.N. Goshchitskiy, Institute of Metal Physics, Ural Department, USSR Academy of Sciences]

[Abstract] The electrical resistivity and the specific heat of $YBa_2Cu_3O_{7-x}$ superconductor material were measured over the 5-300 K temperature range, after specimens had been disordered by neutron bombardment at 80 K temperature for removal of possible thermochemical effects such as those caused by oxygen diffusion. The purpose of the study was to determine the effect of neutron bombardment on the temperature dependence of these two properties of the material. The specimens were monophase ones, according to x-ray diffraction analysis and the steep drop of their magnetic susceptance with full shielding within the temperature range of the superconducting transition. Their post-bombardment critical temperature and temperature dependence of electrical resistivity did not change significantly upon short (20 min) annealing at room temperature. Lengthy (1 month) soaking at 300 K raised the critical temperature and lowered the electrical resistivity slightly, but did not restore them to pre-bombardment levels. After weak bombardment with the neutron flux density varied up to $7 \cdot 10^{18}$ cm^{-2} the electrical resistivity had increased correspondingly but its temperature dependence remained almost linear according to the Matthiessen rule. After strong bombardment with the neutron flux density exceeding 10^{19} cm^{-2} the mechanism of electrical resistivity became exponentially dependent on $F/T^{1/4}$ (F- neutron flux density, T- temperature) with a coefficient changing from one proportional to the temperature at low neutron flux densities to a constant one at high neutron flux densities. Neutron bombardment to a flux density of $2 \cdot 10^{19}$ cm^{-2} had not changed the specific heat appreciably from 100 K up, but did cause an anomalous growth, thereby violating the Bardeen-Cooper-Schrieffer theory below 7 K; this anomaly however, did not have adequate reproducibility. This anomaly is attributable to the effect of neutron bombardment on the electron component of specific heat, its phonon component remaining unchanged. The results indicate a redistribution of oxygen between positions 04 and 05 in the $YBa_2Cu_3O_{7-y}$ structure. Figures 2; references 5: all Russian (2 in English translation).

Evidence Proving Metallic Nature of Chemical Bond as Well as of Concurrent Magnetism and Superconductivity in $Y_{1-x}Fe_xBa_2Cu_3O_d$ With x Ranging from 0.0 to 0.5

18620121c Moscow PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 47 No 4, 25 Feb 88 (manuscript received 31 Dec 87) pp 196-200

[Article by I.S. Lyubutin, Ye.M. Smirnovskaya, V.G. Terziyev, and A.Ya. Shapiro, Institute of Crystallography, USSR Academy of Sciences]

[Abstract] Specimens of 1-2-3-phase $YBa_2Cu_3O_d$ superconducting ceramic containing Fe^{3plus} ions were synthesized for a study of their chemical bond and physical properties, additional charge perturbations in the "Cu sublattice" having been avoided by partial replacement of Y with Fe according to the $Y_{1-x}Fe_xBa_2Cu_3O_d$ formula where x was varied over a 0.0-0.5 range. The results of x-ray diffraction analysis reveal dominance of the 1-2-3 phase with x below 0.2 and encroachment of Fe_2O_3 impurity up to 5-8 percent with x reaching 0.5, the structure remaining rhombic with a slightly increasing lattice parameter throughout the range of x. Moessbauer spectra of ^{57}Fe absorption were recorded and their parameters IS, QS were measured at key temperatures of 295 K, 78 K, 4.2 K. While no changes in the spectra occurred as the temperature was dropped from 295 K to 78 K, significant changes including a magnetic split occurred as the temperature was dropped to 4.2 K. Estimates based on these changes and on the temperature dependence of the magnitude of this split yields an approximately 330 kOe strong magnetic field on ^{57}Fe nuclei, which is close to the magnetic field intensity in metallic alpha-Fe, and thus provide additional proof that the 1-2-3 phase is in a metallic state with concurrent magnetism and superconductivity at 4.2 K. Figures 3; tables 3; references 4: all Western (1 in Russian translation).

Manifestation of Superconductivity in Twinning Planes of High-Temperature Superconductors

18620121d Moscow PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 47 No 4, 25 Feb 88 (manuscript received 11 Jan 88) pp 204-206

[Article by A.A. Abrikosov and A.I. Buzdin; Institute of Theoretical Physics imeni L.D. Landau, USSR Academy of Sciences]

[Abstract] The effect of superconductivity in twinning planes of $YBa_2Cu_3O_{7-d}$ high-temperature superconductors on the specific heat C and the upper critical magnetic field is evaluated analytically, the twinning-plane superconducting transition temperature T_c known to be 4-5 K higher than the bulk superconducting transition temperature T_{cO} and the upper critical magnetic field parallel to the twinning plane known to be radically dependent on the ambient temperature. With a modification of the Ginzburg-Landau functional used for description of twinning-plane superconductivity, the temperature dependence of the twinning-plane specific heat is obtained theoretically from the solution to the corresponding biquadratic algebraic equation for the order parameter. Numerical calculation of C_p/T as a function of T or, in normalized form, as a function of $(T-T_{cO})/T_c-T_{cO})$ for sparse twin structures with L/h (L- distance between twin boundaries, h- characteristic length) typically equal to 12 are compared with experimental data. The slight peaking of the specific heat within the T_{cO} range obtained in measurements is attributable to fluctuation effects. The temperature dependence of the upper critical magnetic field is also evaluated with the aid of the Ginzburg-Landau functional, calculations on this basis yielding a T_c approximately 5-6 K higher than T_{cO}. In a dense twin structure, with L smaller than h, weakening of the proximity effect may raise the twinning-plane superconducting transition temperature T_c, the characteristic length h in turn being dependent on that temperature. The authors thank S.V. Polonskiy and M. Kulich for assisting in numerical calculations and for helpful discussion of several problems. Figures 1; references 14: 5 Russian, 9 Western.

Recording Weak Localization of Electrons in CdS at 77 K by Method of Acoustoelectronic Amplification

18620121e Moscow PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 47 No 4, 25 Feb 88 (manuscript received 5 Nov 87, after revision 18 Jan 88) pp 213-216

[Article by A.M. Dyakonov and Ya.V. Kopelevich; Institute of Engineering Physics imeni A.F. Ioffe, USSR Academy of Sciences]

[Abstract] The possibility of electrons weakly localizing in pure materials and at temperatures above those at which they are known to weakly localize in disordered materials upon elastic scattering by impurities was demonstrated experimentally in CdS at liquid-N_2 temperatures, with electron concentrations of only 10^{12}-10^{13} cm^{-3} and sufficiently low for recording weak localization of electrons upon their scattering by acoustic phonons. It was recorded by the acoustoelectron amplification method, particularly suitable for piezosemiconductor materials such as CdS. The method involves generating a pulsed electric drift field as well as radio pulses and measuring the acoustic pulse signal emitted by a specimen of the material upon application of a magnetic field across it. The equipment for this purpose included, in addition to a radio pulse transmitter and a generator of electric drift pulses with variable time delay each, also a pulse radio receiver, a synchronizer, an oscilloscope, a stroboscope, a digital voltmeter, and a graph plotter. An electron concentration of $5\bullet 10^{12}$ cm^{-3} in the CdS specimen was produced by illuminating the specimen with a stabilized incandescent lamp through a set of light filters. The 5.5.2x6 mm^3 specimen was placed in the airgap of a

variable-strength electromagnet inside a Dewar flask containing liquid nitrogen at 77 K. The duration of electric drift pulses, approximately $3 \cdot 10^{-6}$ s, correspond to the single-transit mode of amplification. The increment of acoustic output signal magnitude was found to increase with increasing intensity of the applied magnetic field, up to saturation at a magnetic field intensity slightly above 1 kOe. Assuming that 1 kOe is the critical magnetic field intensity for decay of interference, the corresponding jerk time of electron phase is the drift time of electronphonon relaxation. The increment of acoustic output signal magnitude was found to decrease with increasing acoustic input power, from maximum to zero as that power was raised from 10^{-5} W to 10^{-2} W, evidently owing to decay of interference in a high-frequency piezoelectric field of a sound wave. The authors thank V.V. Lemanov for support as well as V.V. Afonin, Yu.M. Galperin, and V.L. Gurevich for many discussions of problems concerning physical interpretation of the results. Figures 2; references 13: 6 Russian, 7 Western.

Study of $La_{2-x}Sr_xCuO_{4-y}$ Ceramics by Neutron Method Concerning Temperature Dependence of Their Dynamics and Structure

18620121f Moscow PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 47 No 4, 25 Feb 88 (manuscript received 19 Jan 88) pp 216-220

[Article by A.V. Belushkin, Ye.A. Goremychkin, V. Zayonts, I. Natkanets, and I.L. Sashin, Joint Institute of Nuclear Research, A.R. Kadyrbayev and B.P. Mikhaylov, Institute of Metallurgy imeni A.A. Baykov, USSR Academy of Sciences]

[Abstract] Spectra of neutron diffraction and inelastic scattering in La_2CuO_{4-y} and $La_{1.8}Sr_{0.2}CuO_{4-y}$ ceramics were recorded with a KDSOG Dubna spectrometer in the IBR-2 fast-neutron research reactor at three temperatures (290 K, 77 K, 10 K), for the purpose of studying the dynamics and the structure of these ceramics over that temperature range. While the locations of singularities in the spectra at 290 K were found to agree with earlier data, a new inelastic line about the 6 meV energy level was detected at 77 K and 10 K with a higher intensity at the lower temperature. A preliminary quantitative analysis of this singularity according to the Gaussian model on the Debye distribution and including its convolution with the spectrometer resolution function does not definitively explain this singularity, nor its relation to the superconductivity characteristics of these ceramics, but indicates that the excitation energy corresponds within an order of magnitude to the superconducting transition temperature for the La-Sr-Cu-O system. The authors thank V.V. Sikolenko, S.V. Krasnosvobodnev, S.F. Gundorina, and V.P. Chinayeva for assistance in testing specimens, S.I. Bragin, Ye. Brankovskiy, and V. Ivanskiy for technical assistance in preparation of measurements, V.L. Aksenov and Yu.M. Ostanevich for discussing the results. Figures 3; tables 15: 3 Russian, 12 Western.

Mesoscopic Fluctuations of Superconducting Current Density in Disordered Superconductors

18620121g Moscow PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 47 No 4, 25 Feb 88 (manuscript received 20 Jan 88) pp 221-223

[Article by B.Z. Spivak and A.Yu. Zyuzin, Institute of Engineering Physics imeni A.F. Ioffe, USSR Academy of Sciences]

[Abstract] Superconduction in disordered superconductors is analyzed on the basis of applicable theoretical relations, and the superconduction current density is shown to fluctuate mesoscopically owing to random distribution of impurity. Calculations by perturbation theory, involving summation of its graphs representing normal and anomalous electronic Green's functions in the scattering potential field with subsequent averaging of the current density over reading of this random potential, are made for specimens in the form of a bar or a bar and a ring connected through a bridge. The results reveal that the amplitude of fluctuations can be larger than the average current density. On the basis of the same model phase fluctuations of the order parameter at both ends of a specimen and their difference are calculated, and are found to be anomalously sensitive to variations of the random potential caused either by diffusion of impurity or by relaxation of two-level systems in the case of glasses. The authors thank B.L. Altshuler, B.I. Ivlev, and Yu.V. Sharvin for helpful discussions. Figures 1; references 11: 6 Russian, 5 Western.

Properties of Y-Ba-Cu-O High-Temperature Melt-Grown Superconducting Films

18620121h Moscow PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 47 No 4, 25 Feb 88 (manuscript received 25 Jan 88) pp 224-227

[Article by Yu.A. Astrov and V.S. Vayner, Institute of Engineering Physics imeni A.F. Ioffe, USSR Academy of Sciences]

[Abstract] Films of Ya-Ba-Cu-O high-temperature superconducting ceramics were produced from the melt of the BaO-CuO binary mixture, forming a melt with the molar ratio of its components within a specific range only and completely wetting Y_2O_3 single crystals as active substrates. The melt was made to completely wet 2 mm thick such substrates, whereupon 0.005-0.010 mm thick superconducting films were produced by thermoreactive diffusion. These films were annealed at a temperature of 850 deg C in air for 24 h, or in air 14 h and then in oxygen for 10 h, or in oxygen for 24 h, and subsequently

cooled at a rate of 200 deg C per hour. The quality of the films was established by the standard method of measuring the temperature dependence and the current dependence of their electrical resistance. The results indicate that such films are characterized by a superconducting transition which begins at approximately 90 K and ends 5-10 K below. The temperature dependence of their electrical resistance is a monotonic one, corresponding to metallic behavior, with the electrical resistance along the tail through and below the transition range decreasing less steeply as the current through the film is increased. The existence of a superconducting phase was further confirmed and the transition temperature established by magnetic measurements, specifically of the diamagnetic susceptibility, by the induction method in an alternating magnetic field with the frequency held at 119 Hz and the intensity varied up to 4.5 G. The authors thank V.N. Andreyev for performing the magnetic measurements and F.A. Chudnovskiy for stimulating discussions. Figures 3; references 18: 2 Russian, 16 Western.

02415/09599

UDC (546.562+537.312.62):537.3:538.214

Thermo-E.M.F., Electrical Conductivity, and Magnetic Susceptibility of Super-Conducting Ceramics at Supercritical Temperatures

18620106 Moscow FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 65 No 1, Jan 88 (manuscript received 26 Aug 87) pp 83-91

[Article by V. I. Tsidilkovskiy, Institute of Metal Physics, and I. M. Tsidilkovskiy, Institute of Electrochemistry, Ural Department, USSR Academy of Sciences]

[Abstract] Known experimental data on superconducting ceramics Y-Ba-Cu-O, La-Ba-Cu-O, La-Sr-Cu-O with typical 10^{21}-10^{22} cm^{-3} hole concentration in the normal phase, namely on the temperature dependence of their thermoelectric power and electrical resistivity, are interpreted theoretically in terms of the energy-dependent density of states g equal to smoothly changing g_0 plus sharply changing g_1 and peaking near the Fermi level at supercritical temperatures. First a wide peak characteristic of a degenerate gas with the scale of electrical conductivity change much larger than kT is considered, together with a narrow peak of the order of or less than kT wide attributable to impurities. The postulate of a narrow peak is found to be more plausible and confirms experimental data on other properties of these materials such as the temperature dependence of their electronic paramagnetic susceptibility in a weak magnetic field. The results can be easily extended to a narrow pseudogap $-g_1$. Figures 5; references 10: 4 Russian, 6 Western (1 in Russian translation).

UDC (546.562:537.312.62):535.33/.34

Energy Band Structure of $La_{1.83}Sr_{0.17}CuO_4$ and $YBa_2Cu_3O_7$ High-Temperature Superconducting Compounds

18620106 Moscow FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 65 No 1, Jan 88 (manuscript received 31 Jul 87) pp 204-206

[Article by V. I. Anisimov, V. R. Galakhov, V A. Gubanov, M. A. Korotin, E. Z. Kurmayev, A. I. Likhtenshteyn, S. A. Turzhevskiy, V. M. Cherkashenko. Yu. M. Yarmoshenko, V. P. Antropov, V. L. Kozhevnikov, and G. V. Bazuyev, Institute of Metal Physics and Institute of Chemistry, Ural Department, USSR Academy of Sciences]

[Abstract] The energy band structure of $La_{1.83}Sr_{0.17}CuO_4$ and $YBa_2Cu_3O_7$ compounds with superconducting transition temperatures 37 K and 92 K respectively has been determined on the basis of x-ray emission and x-ray electron spectroscopy as well as calculations by the method of linearized muffin-tin orbitals. Both OK_{alpha} (1s-2p transition) and CuL_{alpha} (2p-3d transition) spectra were recorded by the primary method in an RSM-500 x-ray spectrometer with liquid-nitrogen cooling to 75 K. Both LaL_{beta5} ($2p_{3/2}$-5d transition) and CuK_{beta5} (1s-4p transition) spectra were recorded by the secondary method in x-ray spectrometers with FRS-KD-1 and FRS-KD-2 coordinate detectors. The spectrograms show a strong hybridization of Cu3d and 02p states in both compounds. In the $La_{1.83}Sr_{0.17}CuO_4$ compound they are 3.8 plus or minus 0.5 eV away from the Fermi level and form the valence band, with the intrinsic La5d band above that level. In the $YBa_2Cu_3O_7$ compound d-states populate principally the low-energy region and 02p-states are predominant near the Fermi level so that a distinctly two-band structure exists here. Information about energy states and bands in oxygen atoms of all four types has been obtained, the calculations having made for $YBa_2Cu_3O_7$ and not for $La_{1.83}Sr_{0.17}CuO_4$ but for La_2CuO_4 with a very similar crystal lattice including O_{xy} and O_z atoms instead. Figures 2; references 7: 2 Russian, 5 Western.

2415/9274

Relativistic Effects in Superconducting Ring in Absence of Volumetric Deformations

18620134d Tomsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA in Russian Vol 31 No 3, Mar 88 (manuscript received 10 Apr 86) pp 112-114

[Article by O.Yu. Dinariyev and A.B. Mosolov, VNII-GAZ [All-Union Scientific Research Institute of Natural Gas]]

[Abstract] It is demonstrated that present-day superconductor devices can be used for studying relativistic effects. It was demonstrated in another study that it is

possible to use a superconductor for the detection of inertial forces and gravitation if the Fermi energy shift resulting from volumetric deformations of the crystal lattice is taken into account. In the present study it is demonstrated that the nontrivial structure of the field of spacelike planes orthogonal to the world lines of the points of a superconductor can result in observable aftereffects. It is assumed that volumetric deformations are absent in order not to confuse phenomena of different natures, in that the mechanism of the influence of a gravitational field on the wave function discussed here is realized in addition to gravity-caused volumetric deformations of the superconductor. The case is discussed when a superconducting wire of diameter d in the shape of an open ring of radius r is, in plane space-time, in plane oxy of a certain cartesian coordinate system, oxyz . The ends of the wires, A and B , are at a distance from one another much smaller than d . It is assumed that the ring is rotating around axis oz at a constant angular velocity of ω and there is no electromagnetic field. The ring can be represented in a cylindrical coordinate system as a two-dimensional surface, whereby A and B meet and have a single shared world line. It is shown that a phase difference forms at the ends of the superconductor which can be detected by means of the Josephson junction technique. Expressions are derived for the phase discontinuity at the ends of the superconductor as a function of the radius of the ring and the ring's angular rotational velocity. Figures 1; references 5: 1 Russian, 4 Western.

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Absolute Negative Resistance in Tunnel Contacts of Nonequilibrium Superconductors

18620122d Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 94 No 2, Feb 88 (manuscript received 18 May 1987) pp 303-314

[Article by M.Ye. Gershenzon and M.I. Faley, Radio Engineering and Electronics Institute, USSR Academy of Sciences]

[Abstract] This article describes an experimental study of the absolute negative resistance that occurs in the tunnel contact of superconductors when excess quasiparticles are created in an electrode having a larger energy gap Δ. Quasiparticle injection from an additonal tunnel contact was used to create a nonequilibrium state in the electrode. In the absence of an injection current, the volt-ampere characteristics of all of the detecting tunnel contacts studied could be satisfactorily explained by the theory of single-electron tunneling between superconductors. Absolute negative resistance was observed in the low-temperature region (Δ/kT is much less than 1), wherein the quasiparticle recombination time γ_R is much greater. The experimentally obtained values of γ_R were found to conform well to the theoretical results, and the theoretical expression for tunnel conduction was determined to satisfactorily describe the experimental dependencies found for all of the specimens studied. The tunnel injection used in the study to create a state of nonequilibrium has definite advantages over optical pumping, at least in the stage of studying the main features of absolute negative resistance. Because the exact number of particles injected is known, the tunnel injection method may be used when producing nonequilibrium quasiparticles by using photons, phonons, and other particles—something that can be used to create new types of detectors of these particles based on tunnel contacts of superconductors. Because the results obtained in the experiements on absolute negative resistance can be described by the existing theory, the conditions of implementing absolute negative resistance through the concentration of excess quasiparticles appear valid for a broader class of nonequilibrium distribution functions than previously postulated. References 18: 7 Russian; 11 Western.

12794

Nonstationary Phenomena at Superconductor-Normal Metal Interface During Flow of Current

18620122c Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 94 No 2, Feb 88 pp 259-266

[Article by V.B. Geshkenbeyn and A.V. Sokol, Theoretical Physics Institute imeni L.D. Landau, USSR Academy of Sciences]

[Abstract] An anomalous Josephson effect at the point contact between a normal metal and a superconducter with heavy fermions has been described in the literature several times. In one such case, the point contact between niobium and a superconductor with heavy fermions, the effect lasted all the way up to about 8 K, even though the heavy-fermion compounds under investigation had a superconduction temperature of less than or about 1 K. The effect observed, which consisted of the presence in the volt-ampere characteristic of inflections that are reminiscent of Shapiro steps, is evidently related to the effect of proximity when the superconductive order parameter is induced in a normal metal close to its interface with a semiconductor. This article attempts to explain these phenomena by using nonstationary Ginzburg-Landau equations. Cases of a superconductor-insulator-normal metal [SIN] and superconductor-normal metal [SN] contact were examined. Solutions to the equations were obtained as were the volt-ampere characteristics of the contacts under a direct current and high-frequency irradiation. In the model examined, there were no nonstationary solutions close to the superconductor-normal metal interface, and the volt-ampere characteristics were nonlinear. Upon irradiation, inflections in the volt-ampere characteristics only appeard in the case of the SIN contact, with the distance between the inflections satisfying the usual Josephson relation. A comparison between the model used in the study and experimental data confirmed the model's validity. It also

appeared that the absence of nonstationary solutions close to the interface in the case of a unidimensional contact is justified for a three-dimensionsal contact as well. Figures 3; references: 3 Russian, 7 Western.

12794

Ferromagnetic Film on the Surface of a Superconductor: Possibility of Heterogeneous Magnetic Ordering

18620133d Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 94 No 3, Mar 88 (manuscript received 13 Jul 87) pp 256-261

[Article by A.I. Buzdin and L.N. Bulayevskiy, Physics Institute imeni P.N. Lebedev, USSR Academy of Sciences]

[Abstract] A study is made of the situation when a thin film of ferromagnetic metal is atomized onto the surface of a massive superconductor. Under certain conditions, the magnetic ordering in the film may generate a small-scale domain structure, achieving minimum system energy considering the interaction of magnetic moments with the superconducting electrons entering the film. The most favorable conditions for observation of the transition are created in superconductors with great correlation length and high density of electron states. A similar situation may arise in a superlattice consisting of thick layers of superconductor separated by thin layers of ferromagnetic metal. In this case, the transition in a layer causes a change from two-dimensional to three-dimensional superconducting behavior. Figure 1, references 8: 5 Russian, 3 Western.

6508

Kinetics of Fluctuations in Superconductors at Frequencies Small in Comparison to the Energy Gap

18620133e Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 94 No 3, Mar 88 (manuscript received 13 Jul 87) pp 262-277

[Article by Sh.M. Kogan, and K.E. Nagayev, Institute of Radio Engineering and Electronics, USSR Academy of Sciences]

[Abstract] the purpose of this work was to develop a kinetic theory of low-frequency and smooth fluctuations in superconductors with moderate variation of δ and η with coordinates on the basis of the kinetic equation for fluctuation of the distribution of quasiparticles. The expression for the correlation functions of Langevin lateral fluxes in the equation for quasiparticle distribution is based on the fact that the individual transitions among states in scattering processes on impurities and phonons are not correlated. This means that the collision integral in the kinetic equation is composed of flows of quasiparticles among the various states. A system of equations is derived for the fluctuations of the distribution functions, leading and lagging Green functions, energy gap, current density, calibration-invariant impulse and potential, and expressions are produced for the correlation function of secondary sources in the kinetic equation for quasiparticle distribution. An expression is derived for the impedance of the equilibrium long Josephson junction at frequencies $\omega$with superconducting current through the junction less than the critical current, and for the spectral density of fluctuations in voltage under the same conditions. The low frequency spectral fluctuation density of voltage in the same junction is found at currents exceeding the critical, i.e., under conditions of Josephson generation. References 20: 12 Russian, 8 Western.

6508

Interaction of Twinning-Plane Superconductivity and Bulk Superconductivity in Tin

18620133f Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 94 No 3, Mar 88 (manuscript received 22 Jul 87) pp 311-321

[Article by I.N. Khlyustikov, Institute of Problems of Microelectronic Technology and High-Purity Materials, USSR Academy of Sciences]

[Abstract] Tin specimens containing twins were used to measure the volume of the specimens in the area of supercooled metastable normal phase states. The same specimens were used for repeated measurements of critical twinning plane superconductivity magnetic field measurements which had been published earlier, allowing construction of a full phase diagram of superconductivity for tin specimens containing twins. The direct results of the experiments are graphs of the variation in magnetic moment of specimens as a function of magnetic field, recorded at fixed temperature. Twinning plane superconductivity states are found to be heterogeneous. Figures 3, references 18: 11 Russian, 7 Western.

6508